Fort Pierce Post-Beach Nourishment Hardbottom Monitoring

September 20, 2000

Prepared for:
Jacksonville District
U.S. Army Corps of Engineers
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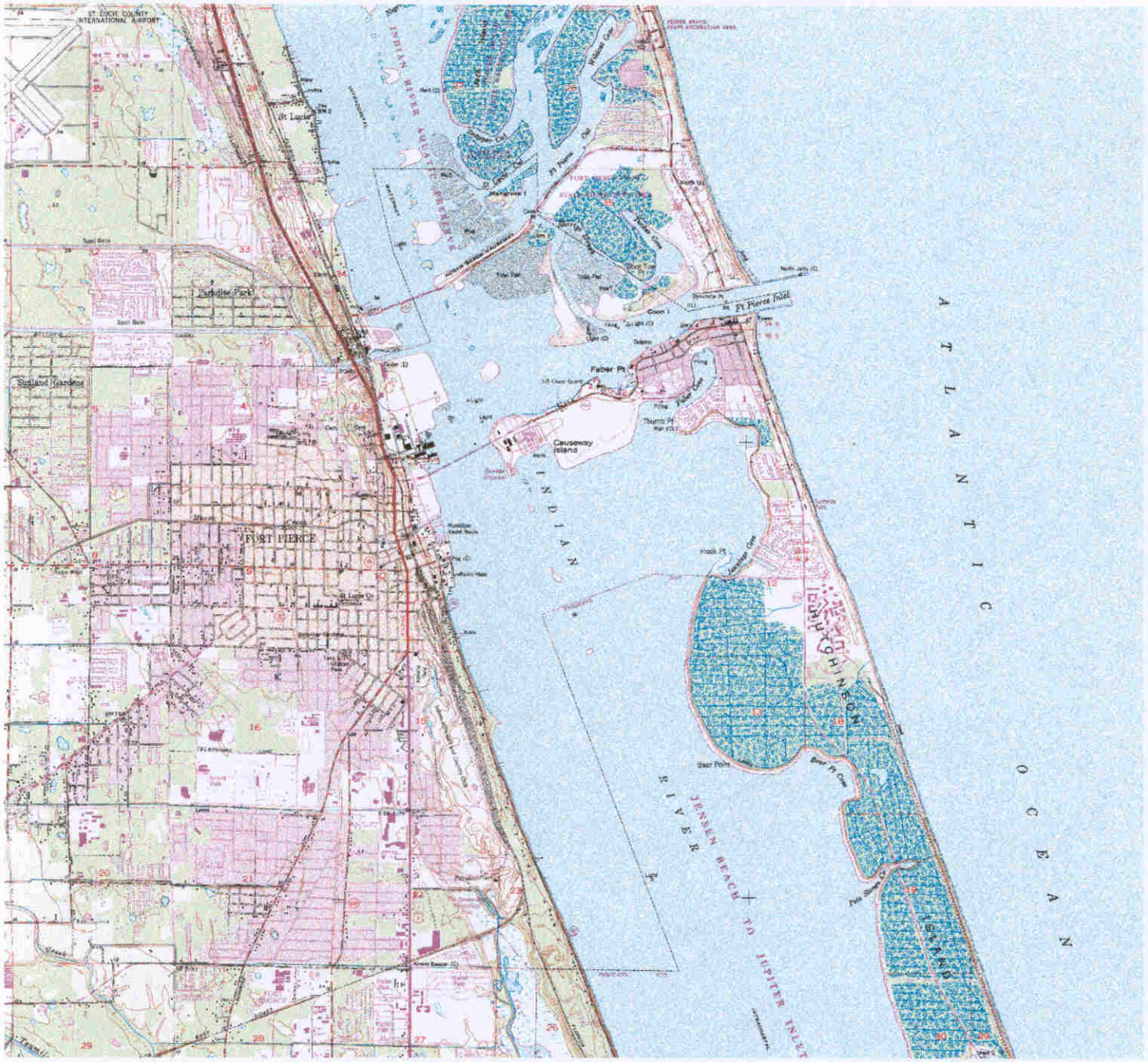
1.0 INTRODUCTION

Dial Cordy and Associates Inc. was authorized by the Jacksonville District U.S. Army Corps of Engineers (USACE) in September 1999 to conduct biological monitoring of the nearshore hardbottom habitat located immediately offshore of Fort Pierce beach, extending a distance of 1.3 miles south of the Fort Pierce Inlet jetty (Figure 1). The authorized Fort Pierce Shore Protection project included maintenance dredging of the ship channel and placement of beach quality sand along the beaches in 1995 and renourishment in 1999. In conjunction with the beach nourishment projects, monitoring of the nearshore hardbottom habitat was required. The purpose of this report is to determine the effects of the 1995 and 1999 beach nourishment projects on hardbottom habitat through monitoring during the summer of 1999 and 2000.

The specific study area for this monitoring event extended at 500-foot intervals south from DNR monument R-34 through R-40. Transects extended seaward 1700 feet from the monuments. Starting and endpoints for the survey transects and the locations of permanent stations to be photodocumented were provided by the Corps of Engineers.

2.0 BACKGROUND

Previous studies of the nearshore hardbottom communities conducted of the subject location have included a baseline pre-nourishment study performed in 1994 by SeaByte Inc. and a post-nourishment monitoring survey in 1996 by Continental Shelf and Associates Inc. (CSA 1997). The baseline study included video mapping along 35 transects parallel to shore between DNR monuments R-34 through R-51 and offshore for a distance of 2000 feet. Permanent photographic stations were selected and established at seven locations. Field observations and photographic analysis were used to characterize the biological communities associated with the hardbottom habitat. Fish species observed and their relative abundance were determined using the methods developed by Stark (1968). The first post-nourishment monitoring was performed on 29 May 1996 using a video mapping system (CSA 1997) to map habitat types along 13 transects between DNR Monuments 34 through 40. Monitoring of the permanent photographic stations was not required of the contractor. Both studies documented the location of nearshore rock outcroppings which occur quite extensively along the Fort Pierce beaches and other areas along the eastern central Florida coastline. The most important or prominent biological feature of this nearshore habitat is the worm rock formed by the sabellariid worm *Phragmatopoma lapidosa*. This species is colonial in nature and can be observed covering nearshore rock outcrops along high-energy beaches where it uses resuspended sand to build worm tubes. These unique worm reefs provide food and habitat for a variety of other marine species (Kirtley 1966, 1974; Kirtley and Tanner 1968; Gore, et al. 1978; Jaap and Hallock 1990; Nelson 1988; and Nelson and Demetriades 1992).



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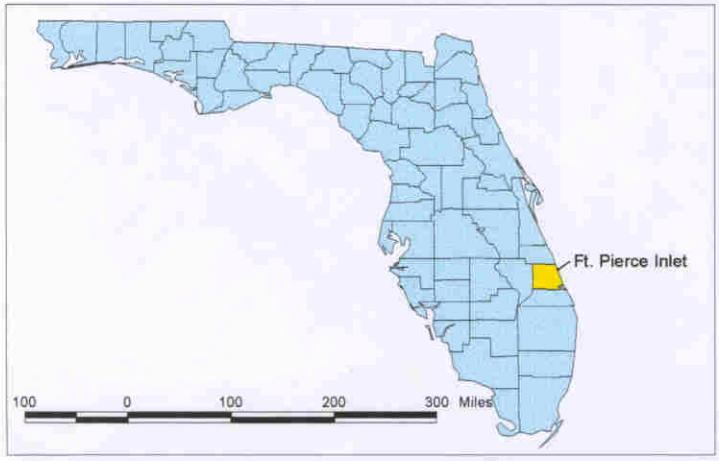


N
W E
S

Location of Study Area	
Ft. Pierce Hard Bottom Monitoring Army Corps of Engineers; Jacksonville District	
Scale: 1" = 5,000'	Drawn By: MR
Date: August, 2000	
DIAL, CORDY AND ASSOCIATES INC Environmental Consultants	J99-318
	Figure 1

3.0 TECHNICAL APPROACH

Monitoring of the nearshore habitat was attempted on February 14-17, 2000. Following repeated attempts to photodocument the habitat, the February survey was cancelled due to poor visibility. Visibility did not improve until May 2000; thus the survey was completed on May 22-26. The May survey included both video mapping along 14 transects and photodocumentation of the permanent stations established in 1994 (SeaByte 1994). A description of the survey techniques utilized is provided in this section.

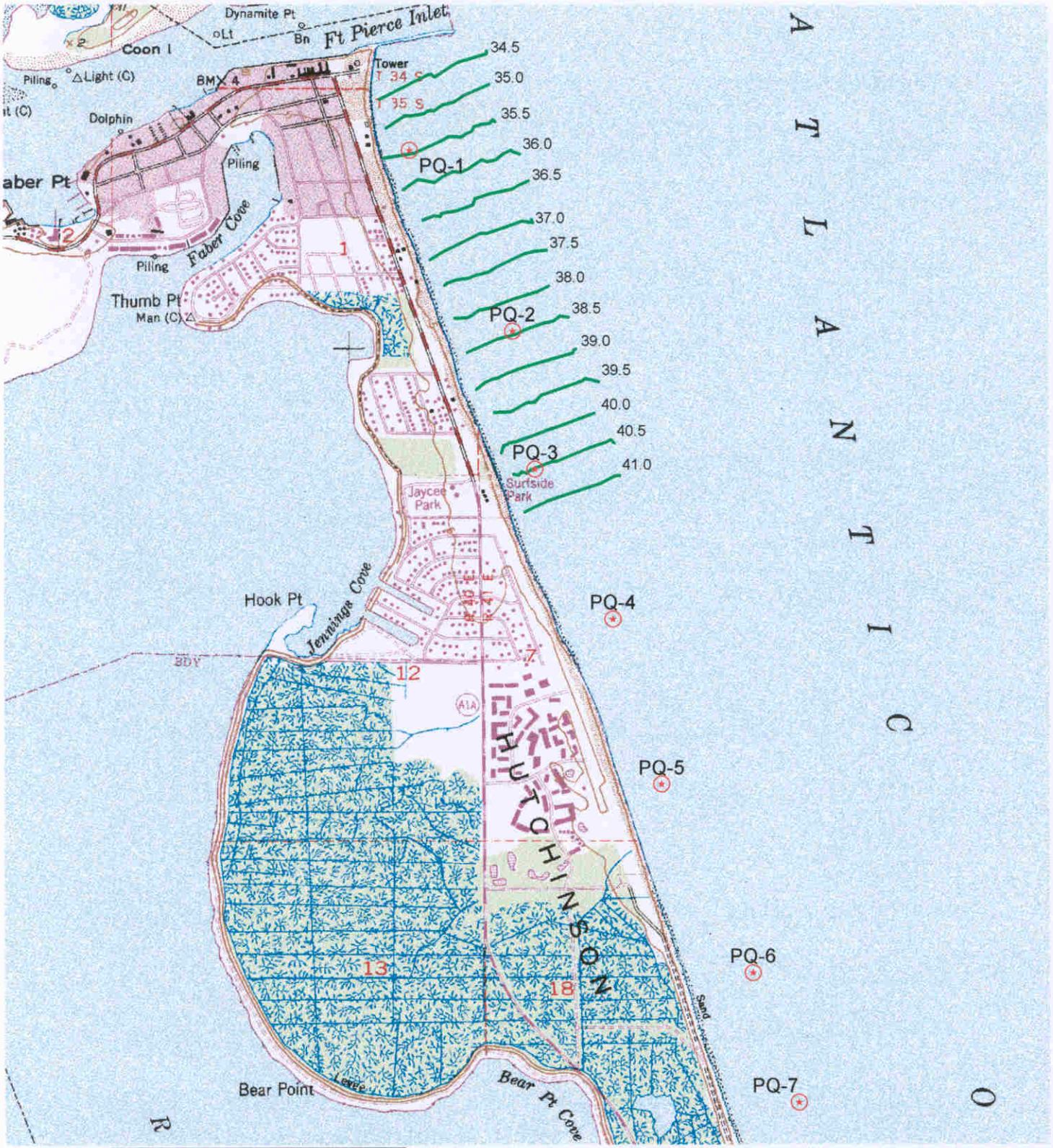
3.1 Video Transects

Mapping of the biological habitat types within the study area was completed utilizing an integrated video mapping system comprised of a towed underwater video system linked to a Trimble DSM212L GPS system and Hypak Navigation software aboard the survey vessel, which allowed for real time recording of the towed video coordinates on the video display. The towed video camera layback distance behind the vessel was determined using an incremental tow line. The incremental distance was incorporated into the navigational database. The high-resolution video camera was towed along 14 transects located at 500 foot intervals between DNR monuments 34.5 and 41 at a speed of 1 kn. and at a height above the bottom of less than 2 feet (Figure 2). Due to recent construction of a southern leg of the south jetty, the transect off DNR R-34 could not be surveyed. Coordinates for the starting and ending points of the transects were provided from previous studies by CSA (1997) and SeaByte, Inc. (1994) and are listed in Table 1. Each transect was approximately 1700 feet in length. The video display on board was reviewed by the principal investigator during the survey to map the substrate types and to document the associated biological communities. Substrate types identified and mapped were consistent with previous reports and included the following:

- Predominantly sand bottom with less than 10% rock cover
- Exposed rock with 10% to 50% algal sponge community cover
- Exposed rock with greater than 50% algal sponge community cover
- Living worm rock

3.2 Permanent Photographic Stations

The locations of the permanent photoquadrats first installed and photographed by SeaByte, Inc. in 1994 were located in the field using the coordinates provided in their report. Of the seven stations, five were found following a 30-45 minute search. In the event the photographic station markers could not be found following one hour of searching, the site was eliminated from further evaluation. The coordinates provided from the previous report ranged from 60-120 feet from the actual station. New coordinates for the stations were taken once each site was located and buoyed (Table 2). Stations PQ-1 and PQ-3 were not found, therefore there is no photodocumentation.



LEGEND

Photoquadrat Stations

Transects

N

W E

S

2000 0 2000 4000 Feet

Location of Survey Transects and Fixed Monitoring Stations	
Ft. Pierce Hard Bottom Monitoring Army Corps of Engineers; Jacksonville District	
Scale: 1" = 2,000'	Drawn By: MR
Date: August, 2000	
DIAL, CORDY AND ASSOCIATES INC Environmental Consultants	J99-318
	Figure 2

Table 1 Coordinates for Video Survey Transects

Transect Line		Easting x	Northing y
34.5	west	730146	1140061
	east	731685	1140762
35	west	730236	1139644
	east	731717	1140280
35.5	west	730202	1139211
	east	731805	1139739
36	west	730487	1138758
	east	732153	1139273
36.5	west	730769	1138317
	east	732284	1138885
37	west	730870	1137742
	east	732330	1138323
37.5	west	731079	1137364
	east	732541	1137877
38	west	731220	1136887
	east	732575	1137354
38.5	west	731399	1136392
	east	732856	1136907
39	west	731535	1135861
	east	732962	1136441
39.5	west	731789	1135526
	east	733289	1135973
40	west	731890	1134945
	east	733221	1135517
40.5	west	732066	1134634
	east	733514	1135089
41	west	732230	1134087
	east	733591	1134614

Florida East Coast State Plane Coordinates (feet)

Table 2 Coordinates Obtained for Permanent Monitoring Stations

Station ID	Easting x	Northing y
PQ-1*	730576	1139325
PQ-2	732053	1136700
PQ-3*	732375	1134707
PQ-4	733489	1132537
PQ-5	734185	1130145
PQ-6	735490	1127418
PQ-7	736143	1125547

Florida East Coast State Plane Coordinates (feet)
* Not Found, Coordinates as Provided by SeaByte Inc. (1994)

In 1994, three rod holes were drilled and permanent steel rods inserted and cemented in place at each station to facilitate duplication of the quantitative sampling (SeaByte Inc. 1994). At each station, three rods were placed in a L-shaped pattern with 5-meters between each rod. Upon relocating these stations in May 2000, a fiberglass tape was stretched between each rod and a continuous line of photographs taken along the two legs of the transect. Photoquadrats were photographed using a Nikonus V underwater camera equipped with a 28mm lens mounted on a camera framer jig. The camera and framer jig system was then placed along the tape from the first rod through the third rod while taking photographs. The area photographed within each frame for analysis was 0.16 m^2 (2.01 ft^2). In each quadrat photographed, the tape was in view as a reference for size and area estimates. Due to the limited visibility (3-5 feet) and excessive floucullent matter in the water column, strobe lights were not used at most stations.

3.3 Data Analysis

3.3.1 Video Analysis

Video for each transect was reviewed following the survey to map the locations of each substrate type. The starting and ending coordinates for substrate types were noted from the video and entered into a GIS database to map the substrate types along each transect. To spatially analyze the estimated total area of each substrate type within the study area, the limits of substrate types were extrapolated between the transects. A mosaic of substrate types was generated from this process. In order to compare baseline video transect mapping in 1994 with the present survey results, habitat maps from the 1994 and 1997 studies were scanned into Arc-View, extrapolated in a similar manner as the 2000 mapped information, and overlayed with the 2000 mapped information. From this composite overlay of temporal mapped information, the percent composition for each substrate type by distance along the transects and by area within the survey block was calculated. Direct habitat loss was calculated by spatially comparing the location of rock features in 1994, 1997, and 2000. Indirect loss was more difficult to isolate from natural changes in rock exposure, however it was assumed that habitat lost immediately seaward of the equilibrium tow line could be considered an indirect impact of the beach fill projects.

The videos were also reviewed to compile a list of marine algae, invertebrates, or fish detectable along the transects. Due to poor visibility the number of species identifiable was limited.

3.3.2 Photoquadrat Analysis

Epibiotic cover was estimated by selecting 10 slides from each station. The 10 selected slides were digitally scanned using a Nikon LS 2000™ slide scanner. The images were then imported into NIH Image™ (an image analysis program). Before digitizing the total area within each slide, the image scale was calculated by digitizing one inch (25.4 mm) from the measuring tape used to delineate and measure the transect. The basal area coverage of each organism was digitized and a percent cover was calculated.

A systematic process was developed to ensure accurate and supportable taxonomy of epibiota censused in the photographic slides. This process involved reviewing the slides and creating a voucher list of organisms (epibiota) that were represented in each station/slide. The next step involved using various sources of information to identify organisms, including: 1) taxonomic guides for visual identifications; 2) species identifications from other photodocumentation reports in similar habitats; 3) scientific publications of species descriptions; and 4) scientific publications of species composition descriptions in similar habitats. Using these materials, each organism was identified to the lowest possible taxonomic level.

4.0 RESULTS

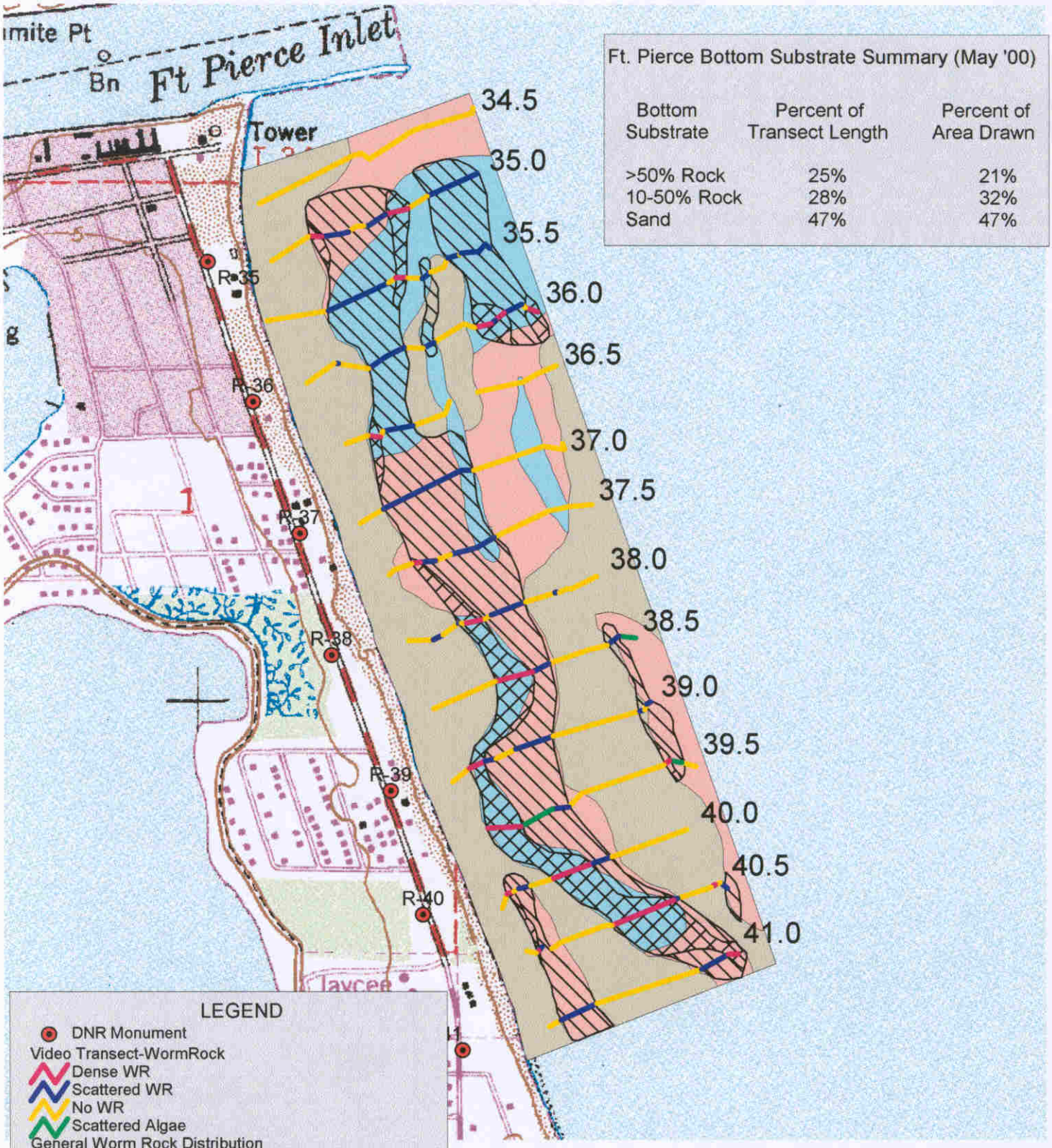
4.1 Video Transect Analysis

This section includes a map and description of the nearshore biotic communities observed along the 14 video transects and a comparison of spatial changes in the substrate types since the initial baseline survey in 1994.

4.1.1 Location and Description of Nearshore Hardbottom

Substrate cover types identified from the video transects and extrapolated for the survey area are illustrated in Figure 3. Patterns for the four substrate categories (sand bottom, sand bottom with less than 10% biotic cover, exposed rock of 10-50% biotic cover, and exposed rock of greater than 50% cover) are shown as different colors, while worm rock distribution and density (dense or scattered) are delineated as cross-hatched symbols.

A summary of the percentage of transect length and area drawn for each substrate type for all transects combined is shown below. The percentage of transect length for each substrate type correlates quite closely to the extrapolated percentage of area represented by the substrate types. By total transect length and total area surveyed, the percentage of exposed rock with at least 10% cover and over 50% cover was 53%, while the remaining total transect length and total area was open sand (47%). During this survey, sand bottom was most commonly observed adjacent to the beach, between the two rock outcrops along the southern half of the survey area, and interspersed between areas of narrow rock outcrops in the northern half of the survey area.



Ft. Pierce Bottom Substrate Summary (May '00)

Bottom Substrate	Percent of Transect Length	Percent of Area Drawn
>50% Rock	25%	21%
10-50% Rock	28%	32%
Sand	47%	47%

General Resource Map Along Survey Transects

Ft. Pierce Hard Bottom Monitoring
Army Corps of Engineers; Jacksonville District

Scale: 1" = 1,000'	Drawn By: MR
Date: August, 2000	
DIAL, CORDY AND ASSOCIATES INC Environmental Consultants	J99-318
	Figure 3

Fort Pierce Bottom Substrate Summary (May 2000)		
Bottom Substrate	Percent of Transect Length	Percent of Area Drawn
> 50% Rock	25%	21%
10-50% Rock	28%	32%
Sand	47%	47%

Worm rock colonies were observed extensively within the first outcrop and less commonly on the outer, more scattered rock outcrops. Areas of dense worm rock cover occurred along the western edge of the first outcrop and, to a lesser degree, on the eastern edge of the first outcrop and offshore outcrops (Figure 3). Colonies ranged from very small, less than 20 cm in diameter, to over 1.5-2 m in height and 2-3 m in diameter. Along many transects, worm rock colonies occurred continuously for distances of over 100 m.

Marine flora and fauna identified from the video survey were limited due to the low visibility during the survey (Table 3) and were generally larger organisms which could be observed from the video. Representative photographs were extracted from the video to show some of the species common to the nearshore habitats (Appendix A). The species list compiled during this survey does not accurately reflect the diversity of marine species associated with the nearshore rock habitat. The 1994 baseline survey was more extensive in scope and provides a more thorough summary of the marine species common to this area (SeaByte 1995).

The algal sponge community present off Fort Pierce is highly characteristic of nearshore rock outcroppings found along the east central and southeast coast of Florida. Marine algae observed included seven species of green algae, dominated by *Caulerpa racemosa, Halimeda sp.,* and *Padina gymnospora;* two species of brown algae, *Dictyota sp*. and *Dictyopteris delicatula*; and three species of red algae including *Bryothamnion seaforthii, Hypnea musciformis,* and *Jania rubens.* Common invertebrates observed included the sponges *Cliona lampa*, *Tethya sp*. and *Anthosigmella varians*; several species of unidentified hydroids and the star coral, *Siderastrea radians*; bryozoans; and two species of sea urchins, including *Echinometra lucunter* and *Lytechinus variegatis.* The polychaete worm, *Phragmatopoma lapidosa,* forms the extensive colonies of worm located off Fort Pierce.

Fish species observed during the video survey on or near hard substrate included Sergeant Major (*Abudefduf saxatilis),* Black Margate (*Anisotremus surinamensis),* Sheepshead (*Archosargus probatocephalus),* Hairy Blenny (*Labrisomus nuchipinnis),* and the Cocoa Damselfish (*Pomacentrus variabilis).* Species observed over sand bottom included Spottail Pinfish (*Diplodus holbrooki)* and Yellowfin Mojarra (*Gerres cinereus).* Low visibility during the survey likely reduced the observers' view of the diversity of species actually present.

Table 3 Marine Species Identified from Video Transects off Fort Pierce, May 2000

MARINE ALGAE

Chlorophyta (Green Algae)

Caulerpa racemosa
Caulerpa prolifera
Caulerpa sertularoides
Codium isthocladium
Cladophora sp.
Halimeda discoidea
Padina gymnospora

Phaeophyta (Brown Algae)

Dictyota spp.
Dictyopteris delicatula

Rhodophyta (Red Algae)

Bryothamnion seaforthii
Hypnea musciformis
Jania rubens

INVERTEBRATES

Porifera (Sponges)

Anthosigmella varians
Cliona lampa
Cinachyra alloclada

Coelenterates (corals, hydroids, and anemones)

Obelia hyanlina (hydroid)
Sertularia flowersi (hydroid)
Siderastrea radians (ahermatypic coral – star coral)

Bryozoans

Bryozoan spp.

Echinodermata (see urchins)

Echinometra lucunter.
Lytechinus variegatus

Ascideans

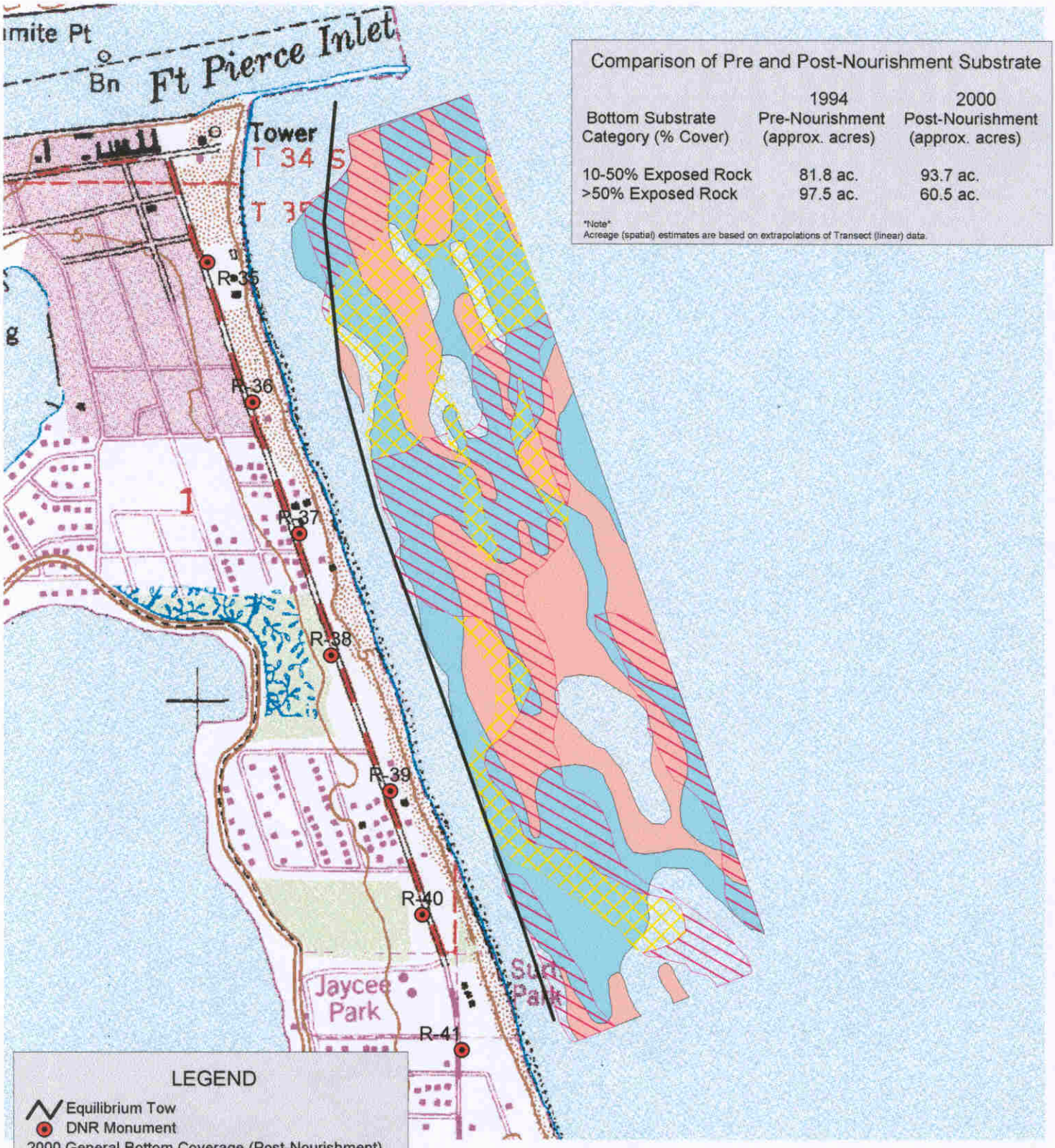
Ascidean spp.

Polychaeta (Segmented Worms)

Phragmatopoma lapidosa

FISH

Abudefduf saxatillis	sergeant major
Anisotremus surinamemsis	black margate
Archosargus probatocephalus	sheepshead
Caranx bartholomaei	yellow jack
Diplodus holbrooki	spottail pinfish
Gerres cinereus	yellowfin mojarra
Haemulon parrai	sailors choice
Halichoeres bivattatus	slippery dick
Labrisomus nuchipinnis	hairy blenny
Pomacantus variabilis	cocoa damselfish
Thalassoma bifasciatum	bluehead wrasse



Pre and Post-Nourishment Project Nearshore Resources	
Ft. Pierce Hard Bottom Monitoring Army Corps of Engineers; Jacksonville District	
Scale: 1" = 1,000'	Drawn By: MR
Date: August, 2000	
DIAL, CORDY AND ASSOCIATES INC Environmental Consultants	J99-318
	Figure 4

4.1.2 Comparison to Previous Monitoring Studies

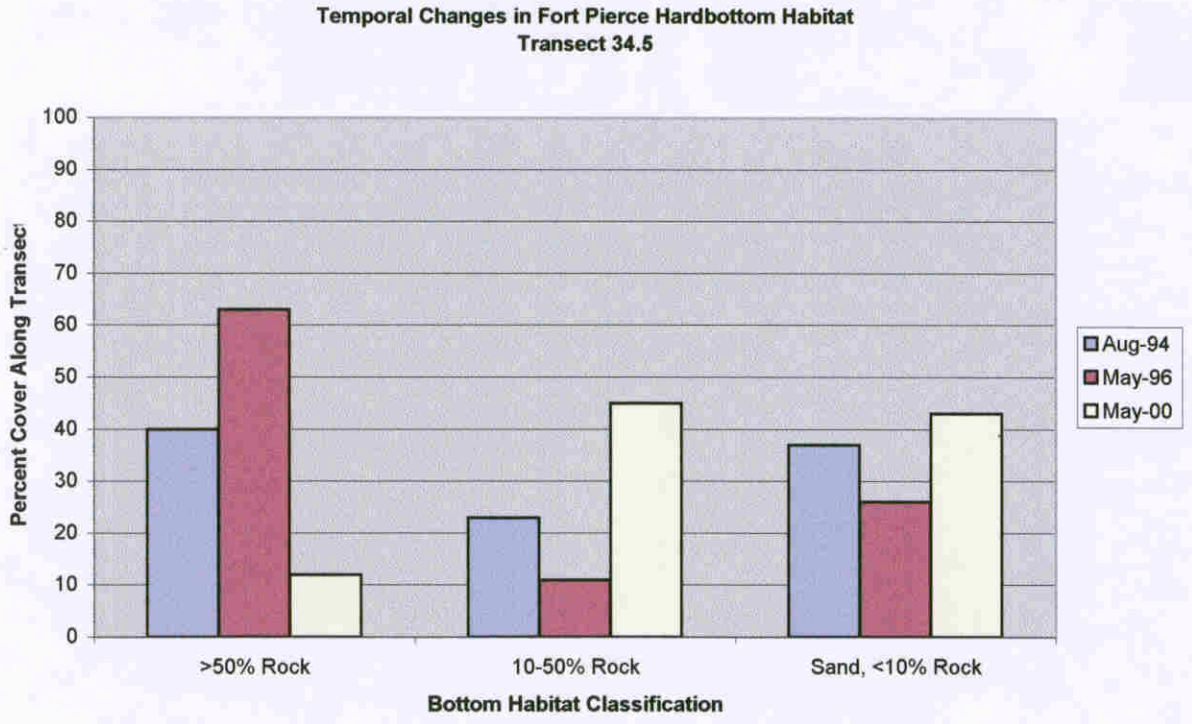
Nearshore rock habitat is highly ephemeral and undergoes major seasonal and year-to-year changes in exposure. Sediment transport and depositional patterns south of Fort Pierce Inlet are highly dynamic, especially following the placement of sand in 1995 and 1999 on the beach south of the inlet. Spatial changes in the substrate cover types mapped in 1994 and for this survey, as shown in Figure 4, illustrate the dynamic changes which have occurred south of the jetty since the baseline survey was completed in 1994. While this overlay is quite complex, it visually shows where changes in substrate and cover types occurred within the study area. While the area of exposed rock with 10-50% biotic cover increased from 81.8acres to 93.7acres, the area of exposed rock with greater than 50% cover decreased from 97.5 acres to 60.5 acres. Reduction in the later substrate type occurred throughout the study area at both inshore and offshore outcrop locations.

A comparisons of temporal changes (1994-2000) in substrate types along each video transect line are illustrated in Figures 5-11. Trends in distribution between the three substrate types are highly similar for transects 34.5 through 39.5, including an increase in the greater than 50% substrate type between 1994 and 1997, followed by a significant reduction in cover by this type from 1997 to 2000. The 10-50% rock cover substrate type declined from 1994 to 1997 and increased from 1997 to 2000 to at least the 1994 percent cover or much greater. The sand, less than 10% substrate cover type, generally increased at most transects over time from 1994 to 1997 and 2000. For transects 40 and 40.5, the greater than 50% cover type declined between 1994 and 2000, coinciding with an increase in the sand, less than 10% cover type. For transects 40.5 and 41, no substrate cover data was available from the 1997 survey report, thus interpreting temporal changes in the percent cover of substrate types for all three events could not be done. For transect 41, no trends could be observed due to inadequate temporal data.

Temporal changes from 1994 through 2000 in worm rock distribution along each transect are quite varied, showing increases in percent cover off two transects, reductions in percent cover off nine transects, and relatively no change in percent cover along three transects (Figure 12). Averaged for all the transects, the percentage of dense worm rock did not significantly change (12% to 11%) while the percentage of scattered worm rock declined from 43% to 25%.

4.2 Fixed Photographic Analysis

This section describes the percent cover of identifiable flora and fauna observed within the photoquadrats at each fixed station and analyzes changes which have occurred since 1994.



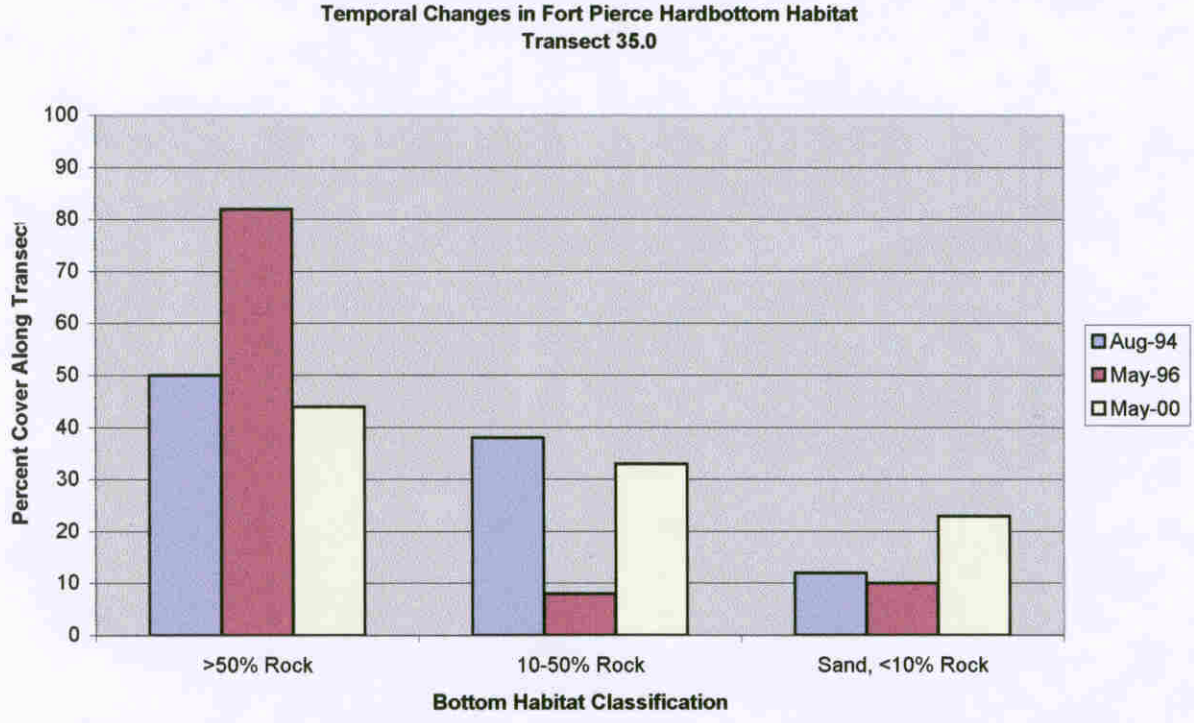
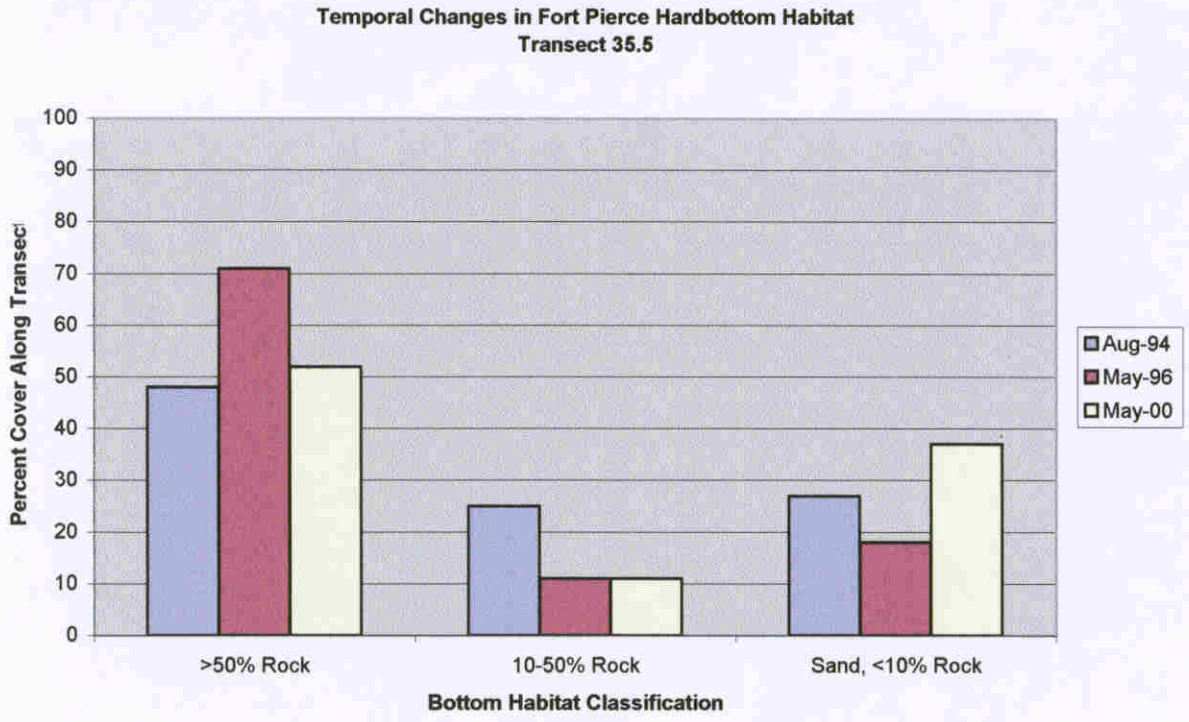


Figure 5. Bottom Cover Comparisons Between Survey Dates for Transects 34.5 and 35



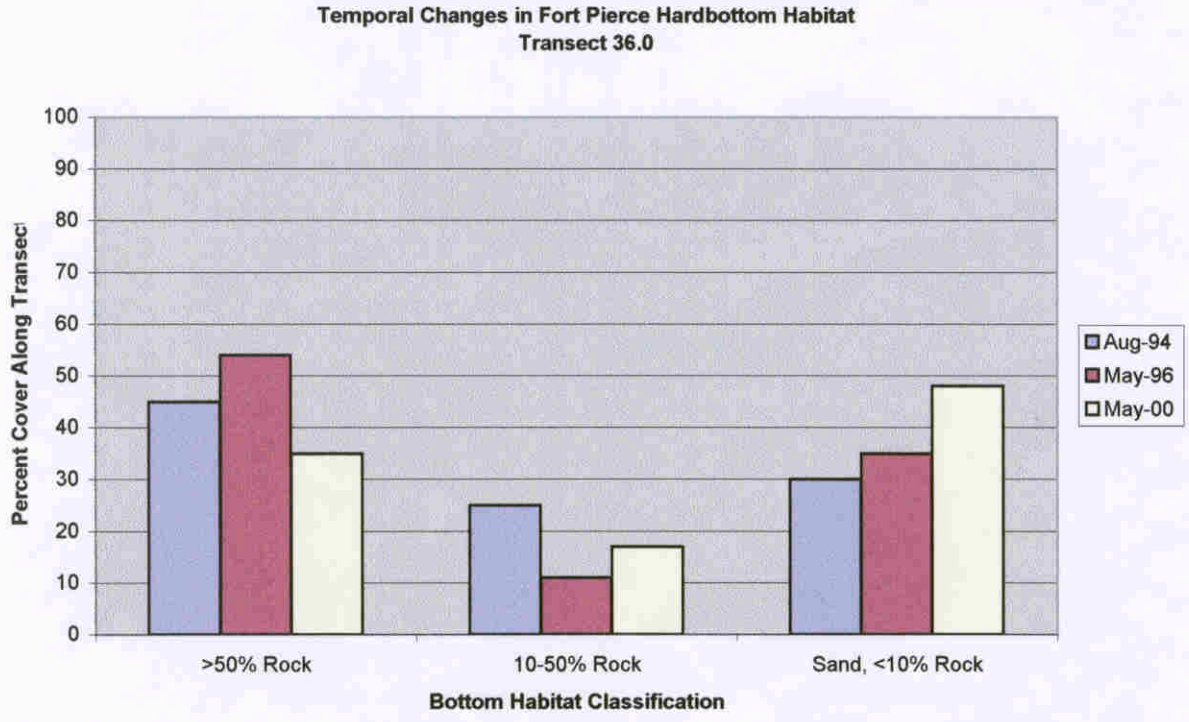
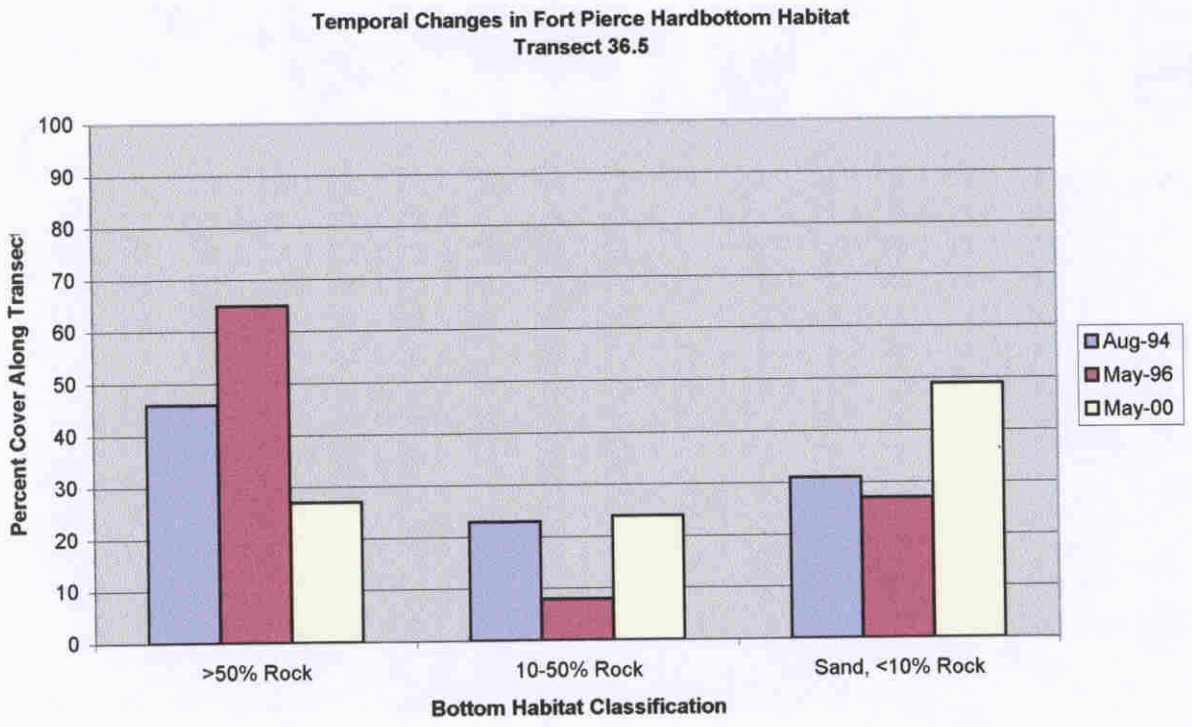


Figure 6. Bottom Cover Comparisons Between Survey Dates for Transects 35.5 and 36



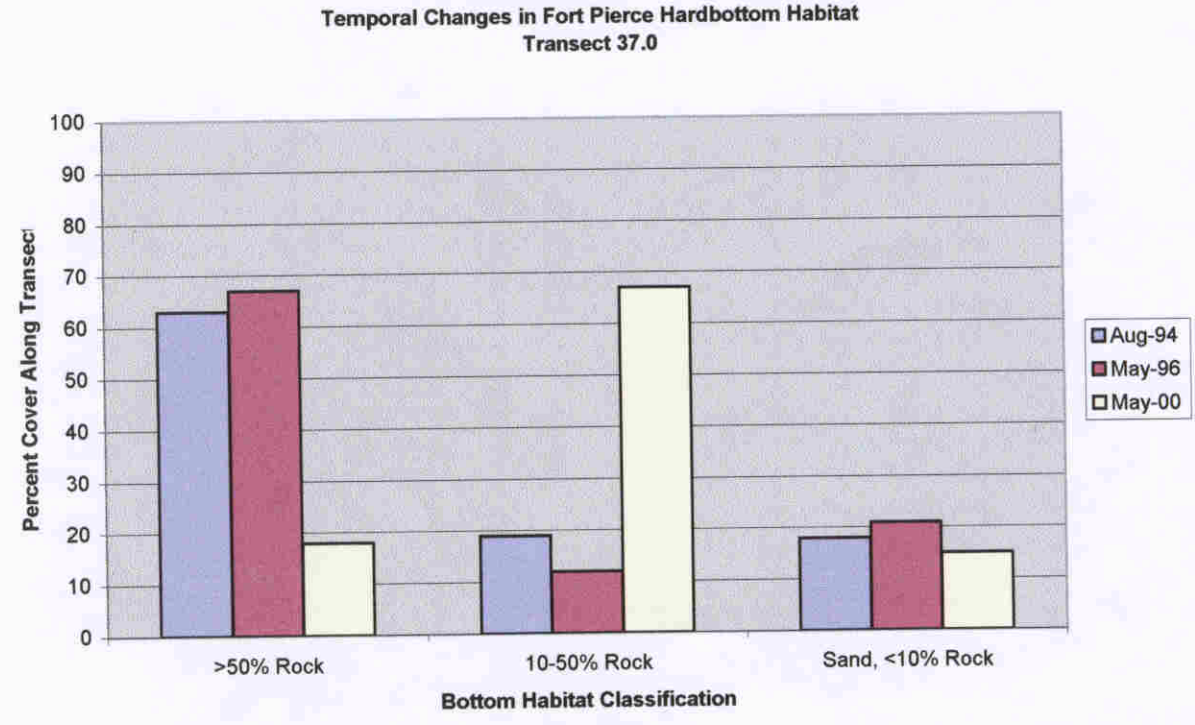
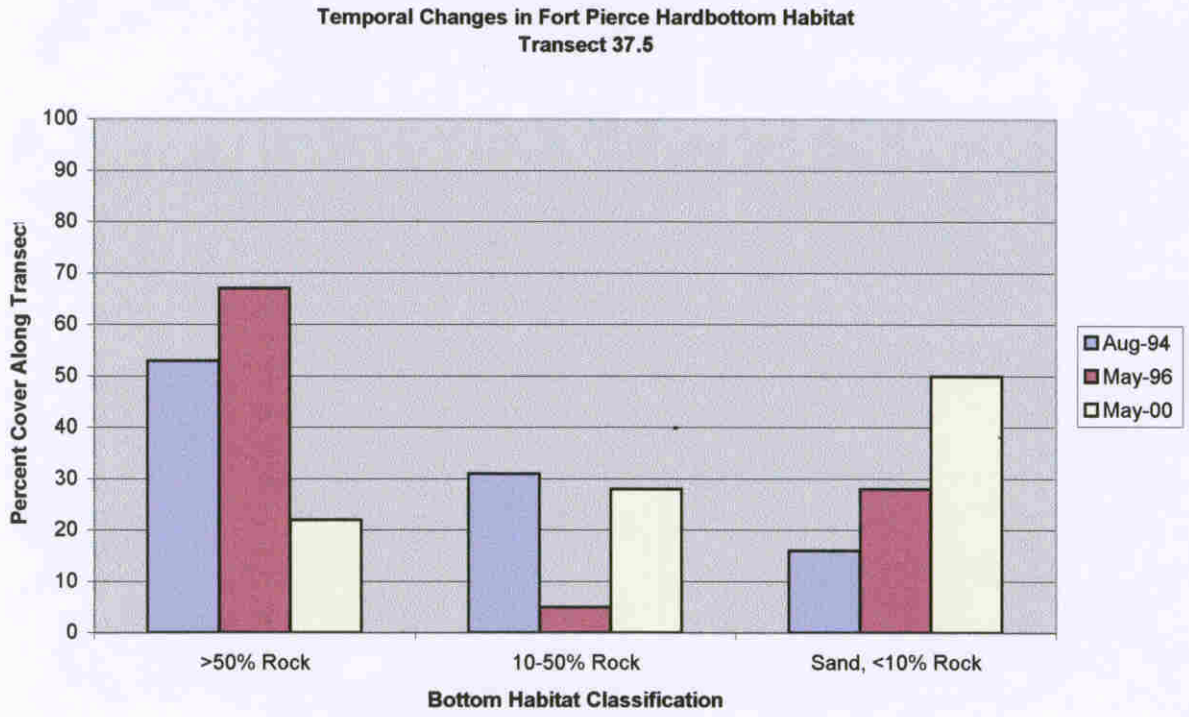


Figure 7. Bottom Cover Comparisons Between Survey Dates for Transects 36.5 and 37



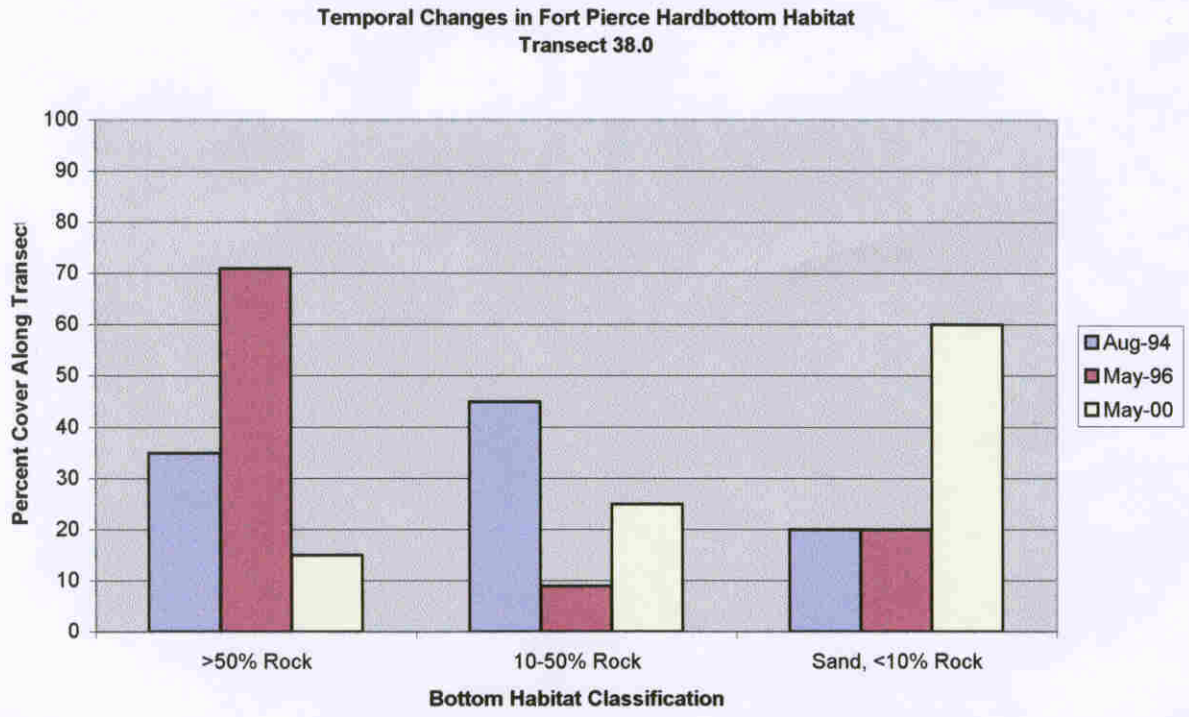
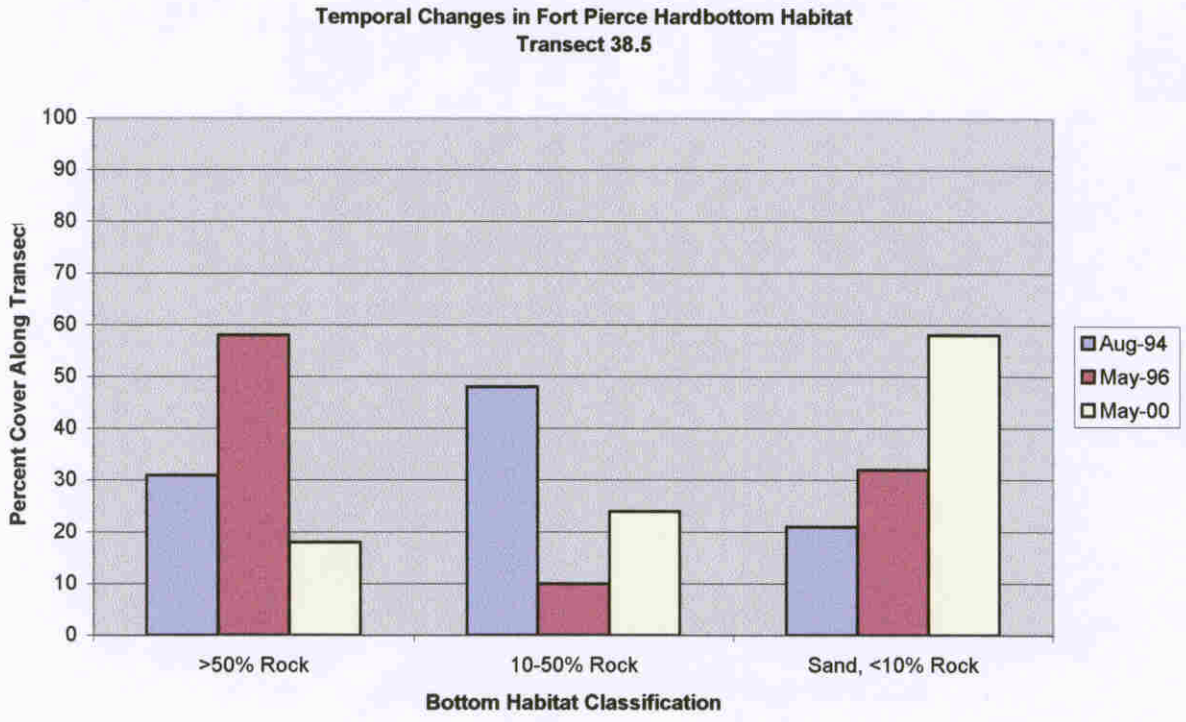


Figure 8. Bottom Cover Comparisons Between Survey Dates for Transects 37.5 and 38



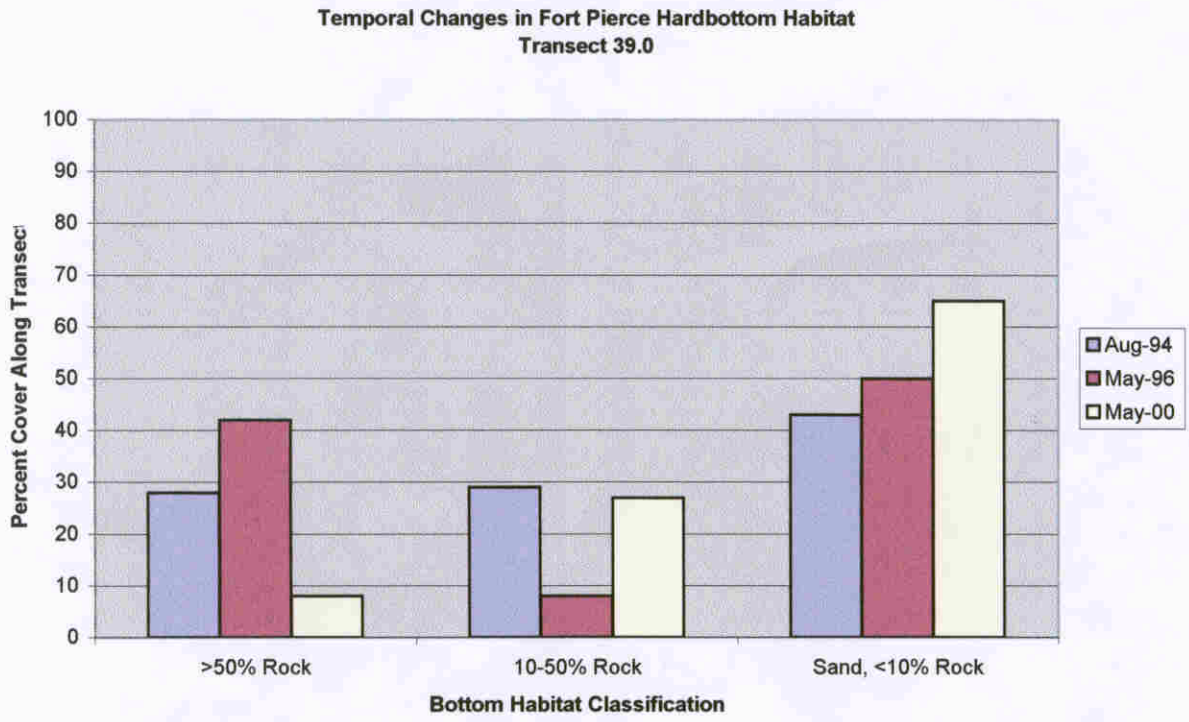
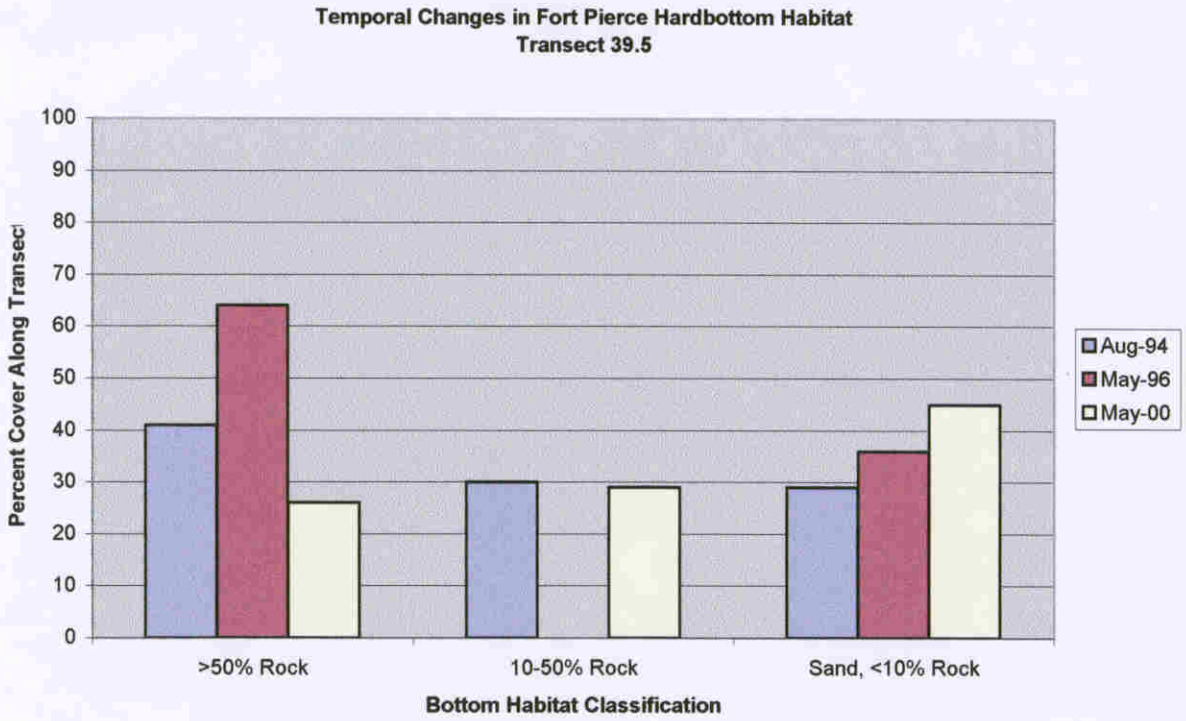


Figure 9. Bottom Cover Comparisons Between Survey Dates for Transects 38.5 and 39



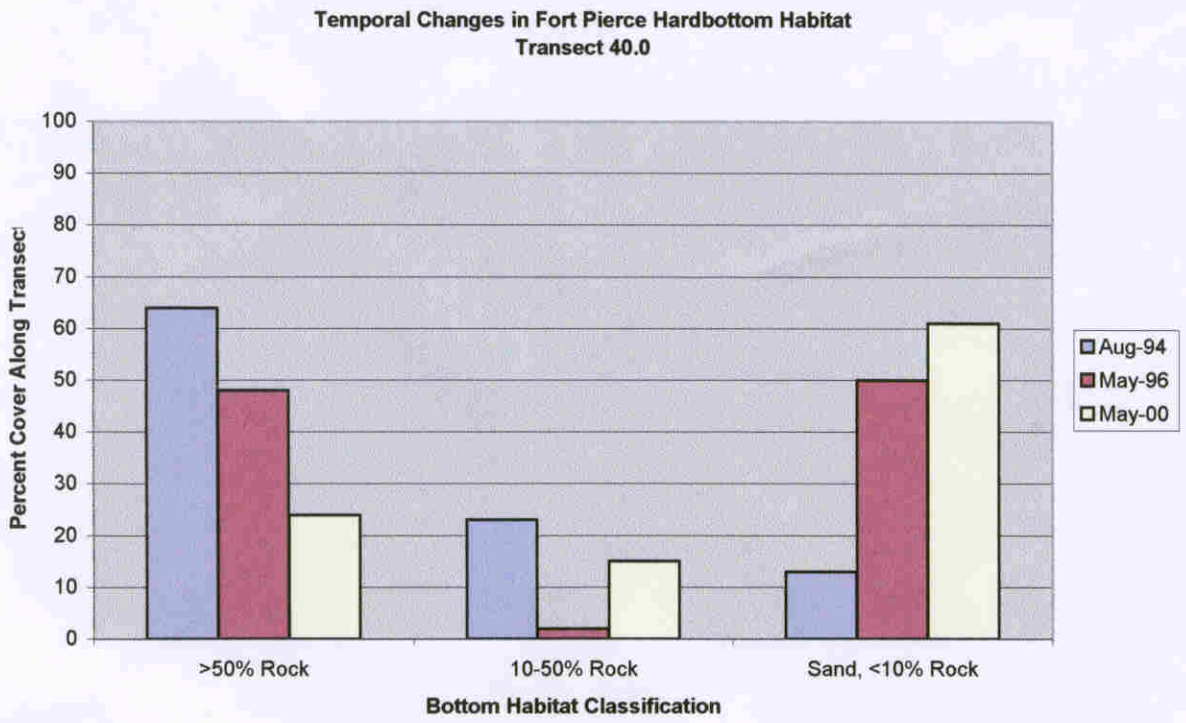
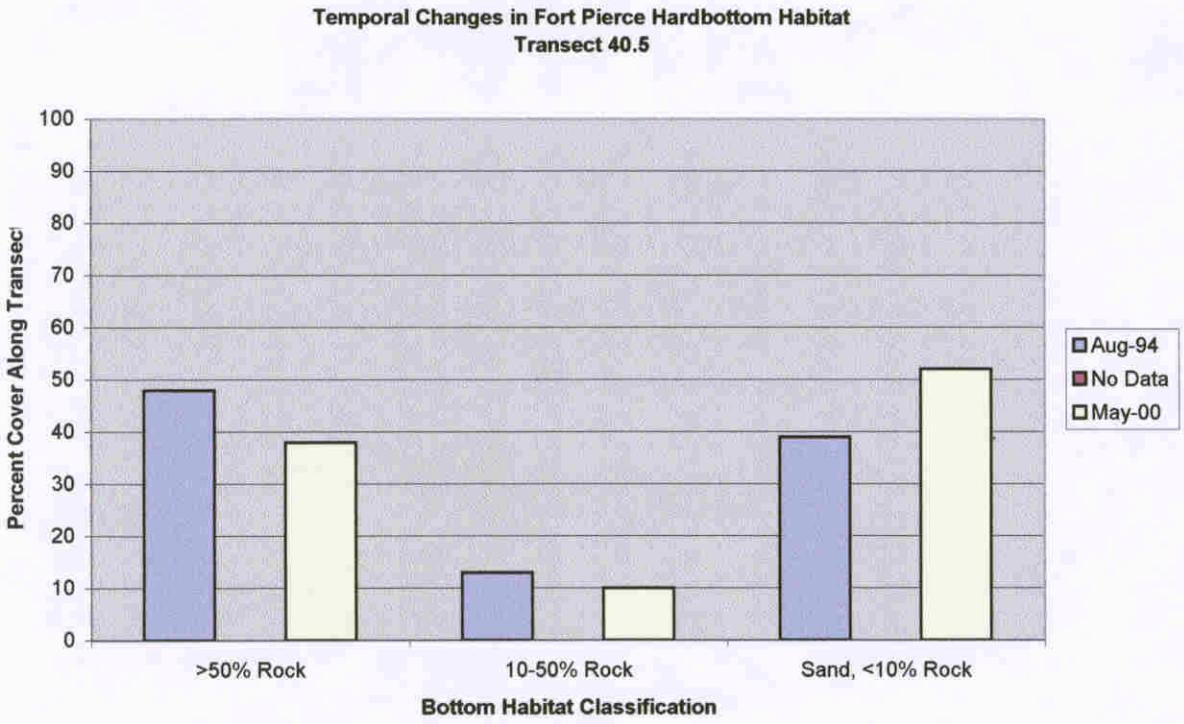


Figure 10. Bottom Cover Comparisons Between Survey Dates for Transects 39.5 and 40



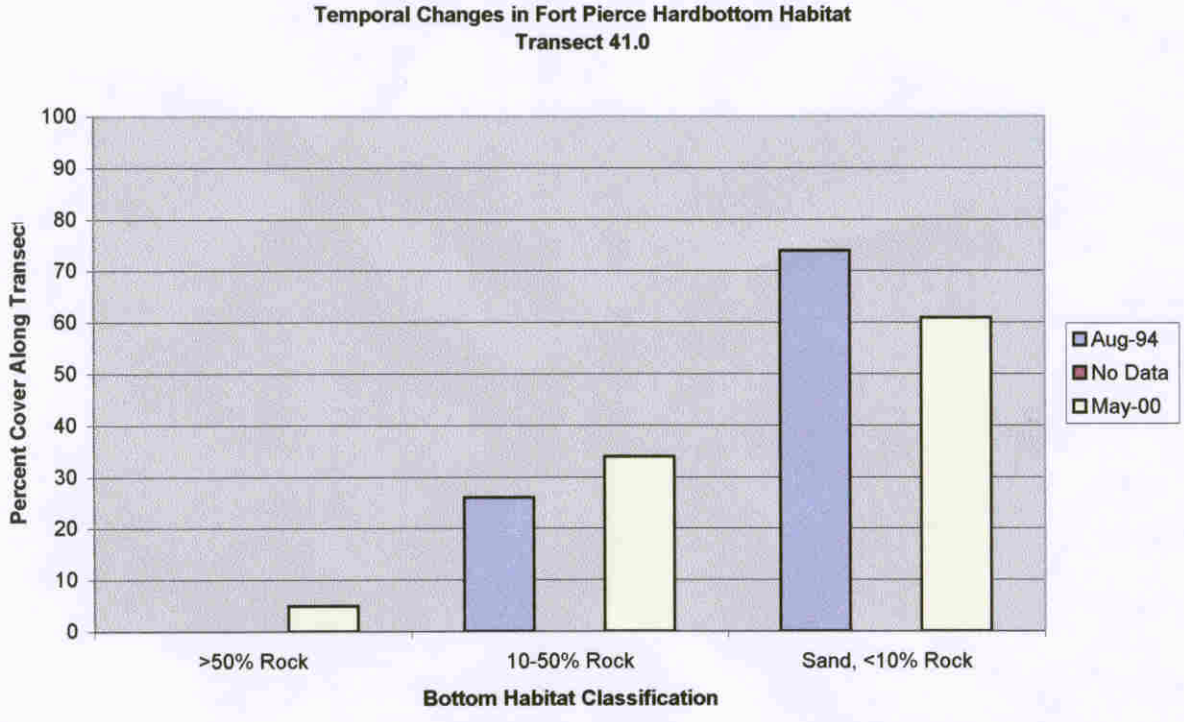


Figure 11. Bottom Cover Comparisons Between Survey Dates for Transects 40.5 and 41

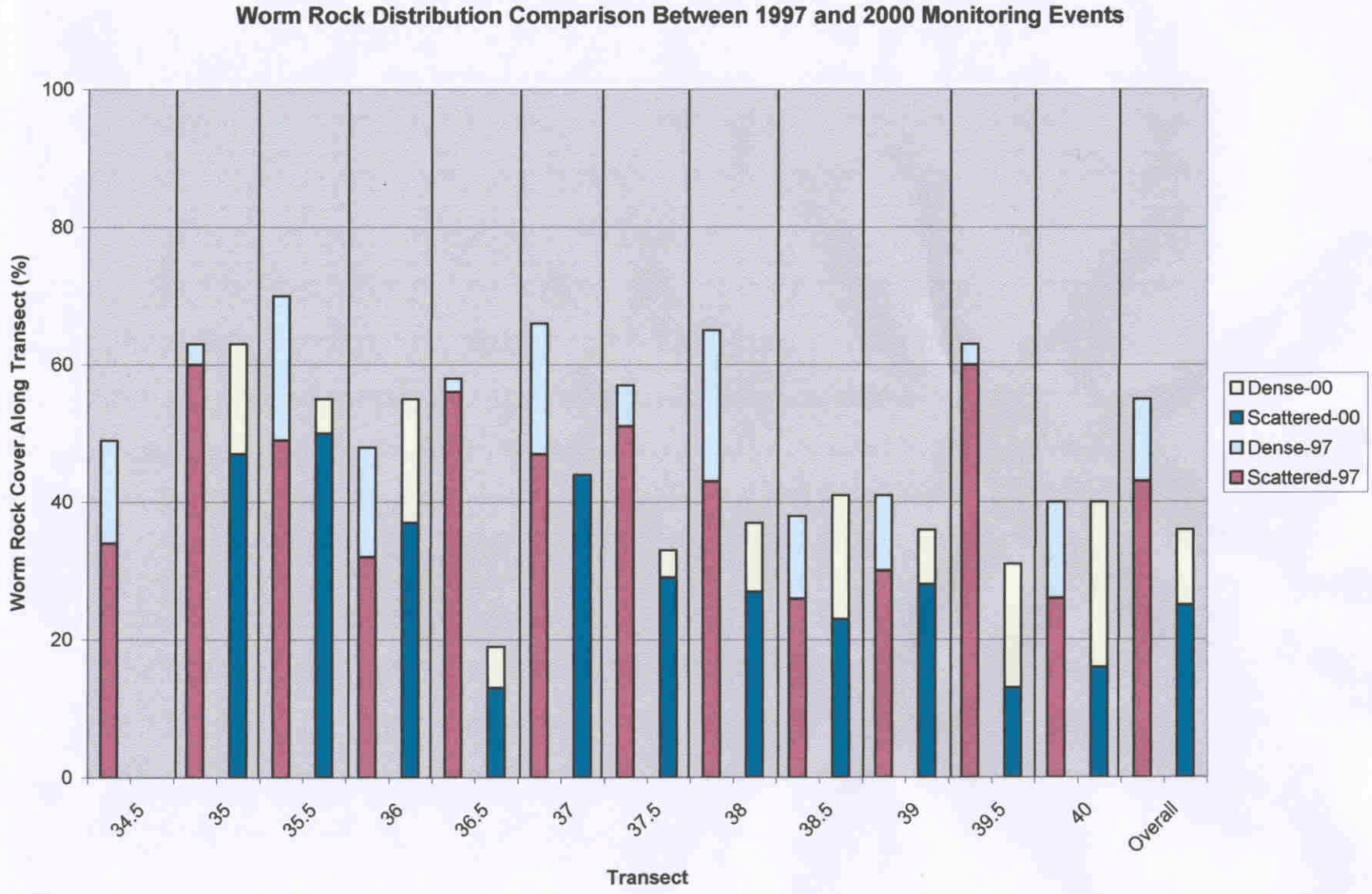


Figure 12. Worm Rock Distribution Comparison Between 1997 and 2000 Monitoring Events

4.2.1 Fixed Photographic Analysis of Hardbottom Cover

The percent cover of biota (plant and animal) and substrate identified from photoquadrats located at the 5 stations found are presented in Table 4. A total of ten photographs were analyzed from each station. Visibility at Station PQ-2 was so limited that analysis of the photographs from this station could not be completed. It is also apparent that due to limited visibility the number of taxa detected from the visual analysis was low. Detailed results of the photoquadrat analysis are listed in Table A, Appendix A. As discussed in Section 2.0, Stations PQ-1 and PQ-3 could not be found following an exhaustive search.

The most common species observed at three of the four stations was *Echinometra lucunter*. *Lytechinus variegatus* was common at Stations PQ-4 and PQ-5. Worm rock colonies formed by *Phragmatopoma lapidosa* occurred at four stations ranging in mean area from less than one percent at PQ-4, PQ-5 and PQ-6 to 18% at Station PQ-7, the station furthermost south. Due to limited visibility, marine algae may have covered more area of the exposed rocks than found through photographic analysis. Substrate, either rock or sand/shell, accounted for over 95% of the total area analyzed. Rock coverage at Station PQ-7 was 79.8% due to the abundant cover of worm rock observed (18%). No spatial differences were apparent from the data presented except for an increase in worm rock cover at the southern study area limit and the lack of urchins observed at the southern inshore station (PQ-6) as compared to the other stations which were further offshore (PQ-4, 5, and 7).

4.2.2 Comparison to Previous Monitoring Studies

In comparison to the photoquadrat analysis performed in September 1994 (SeaByte 1994), the cover area of animals and plants were significantly less during the present monitoring event than previously observed. Biotic cover in 1994 ranged from 70-78% at Stations PQ-4-7 and from less than one percent to 20% during the present study. While the dominant marine species were present during both studies, the total area of biotic cover significantly declined. This decline is likely due to a number of factors including the inability to accurately analyze photoquadrats in the present study due to the limited visibility, the differential growth rates of marine algae, the ephemeral nature of this shallow nearshore habitat, scouring of the rock habitat by sand in transport, and the frequency and severity of storms since 1994 which has direct effects on algal cover.

Table 4 Summary of Photoquadrat Analysis at Permanent Monitoring Stations PQ4, PQ5, PQ6, and PQ7

Station PQ4	**Area mm^2**	**(n/10)**	**% Coverage**
Echinometra lucunter	53837870.28	5383787.03	4.00560%
Lytechinus variegatus	5782157	578215.7	0.43020%
Unid. Sponge	33223.32	3322.332	0.00247%
Unid. Hydroids	56699.72	5669.972	0.00422%
Phragmatopoma lapidosa	69328.5	6932.85	0.00516%
Substrate (rock-sand, shell)	1284714679	128471468	95.58%
Total Area	1625326434	162532643	100.00%
Station PQ5	**Area mm^2**	**(n/10)**	**% Coverage**
Echinometra lucunter	28207.69	2820.769	0.01499%
Lytechinus variegatus	7801.91	780.191	0.00415%
Unid. Green Algae	67169.49	6716.949	0.03570%
Phragmatopoma lapidosa	446536.59	44653.659	0.23733%
Substrate (rock)	186730517.7	18673051.8	99.24708%
Total Area	188147107.2	18814710.7	100.00%
Station PQ6	**Area mm^2**	**(n/10)**	**% Coverage**
Phragmatopoma lapidosa	349343.54	34934.354	0.0323%
Cliona deltrix	52857.02	5285.702	0.0049%
Unid. Green Algae	110444.34	11044.434	0.0102%
Substrate (rock)	1080535473.11	108053547	99.9558%
Total Area	1081012984.25	108101298	100.00%
Station PQ7	**Area mm^2**	**(n/10)**	**% Coverage**
Echinometra lucunter	79920.81	7992.081	2.46136%
Cliona delitrix	4381.73	438.173	0.13495%
Phragmatopoma lapidosa	584755.42	58475.542	18.00903%
Substrate (rock)	2593687.13	259368.713	79.87919%
Total Area	3247012.31	324701.231	100.00%

5.0 IMPACT ASSESSMENT

Impacts to the nearshore rock habitat and associated biological communities include both direct and indirect impacts. Direct impact refers to the area of rock habitat located landward of the design tow of beach fill which was covered by the placement of sand on the beach. Indirect impacts include loss of rock habitat seaward of tow of fill line which could be indirectly tied to the nourishment projects, through transport from the beach and deposition on rock habitat offshore, scouring and loss of biotic cover from sand in suspension, and the reduction in biotic cover on rock outcrops. An analysis of direct impacts and indirect impacts is provided below.

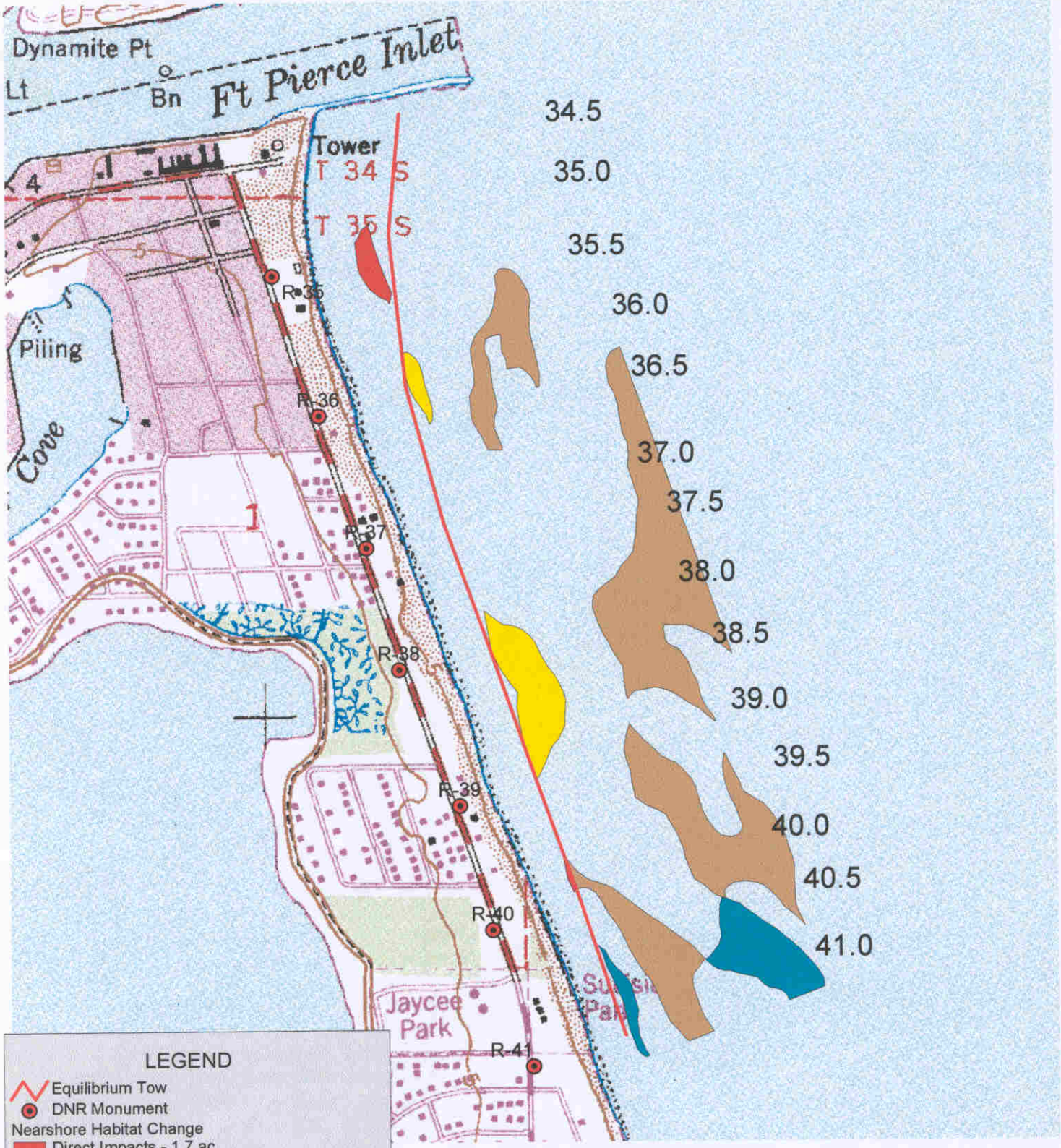
5.1 Direct Habitat Loss

The direct habitat lost since the 1994 baseline mapping of the nearshore rock habitat was calculated by spatially analyzing the pre and post-nourishment locations of rock habitat landward of the equilibrium tow of fill limits (Figure 12). Based on this analysis 1.7 acres of rock habitat and associated biological community were directly lost as a result of the 1995 and/or 1999 projects. This loss was higher quality habitat characterized as exposed rock with greater than 50% algal-sponge community cover.

5.2 Indirect Impacts

Changes in habitat cover type which occurred outside the fill limit included a loss of 8.3 acres of exposed rock with greater than 50% cover and 10-50% cover immediately seaward of the equilibrium tow of fill, and a reduction in 52.2 acres of habitat originally classified as exposed rock with greater than 50% cover or 10-50% cover to a cover type of sand, less than 10% exposed rock (Figure 13). An area of 8.4 acres classified as sand, less than10% exposed rock in 1994 was found to be exposed rock with 10-50% cover in 2000.

Whether these changes in cover type can truly be considered indirect impacts is questionable due to the natural dynamic changes inherent to nearshore rock habitat, however it is probable that the 8.3 acres of habitat indirectly lost immediately seaward of the equilibrium tow line is a result of stabilization of the beach profile and movement and redeposition of sand from the beach seaward over the rock outcrops. The only persistent features are the 3-foot ledges at the inner and outer reaches of rock platforms observed. Changes in the classification of cover types could be a result of seasonal differences in the occurrence of common marine flora and fauna, temporary or seasonal deposition of a thin layer of sand over the level rock platform, the frequency and severity of storm events since the restoration projects, or other physical factors influencing the ephemeral exposure of rock and biotic cover. Since the original location of the sand residing over the former rock habitat with biotic cover during the 2000



Location of Nearshore Habitat Changes Over Time	
Ft. Pierce Hard Bottom Monitoring Army Corps of Engineers; Jacksonville District	
Scale: 1" = 1,000'	Drawn By: MR
Date: August, 2000	
DIAL, CORDY AND ASSOCIATES INC Environmental Consultants	J99-318
	Figure 13

survey is unknown, these changes in substrate cover types discussed above can not solely be attributable to the beach restoration projects. While some of these observed changes may, in fact, be considered indirect impacts from the beach restoration projects, the exact area of impact can not be determined with the available information.

6.0 SUMMARY AND CONCLUSION

Monitoring of the nearshore hardbottom habitat off Fort Pierce was conducted from May 22-26, 2000. An earlier attempt during the winter was made, however, visibility proved too poor to complete. The survey included video mapping of substrate cover types along 14 transects extending 1700 feet offshore of DNR monuments R-34.5 through R-41 and photographic analysis of the biological communities found at five permanent monitoring stations installed in 1994. The purpose of the monitoring was to ascertain the condition of the nearshore rock habitat and associated biological communities in the summer of 2000 as compared to pre-nourishment conditions characterized in 1994 and again in 1997 after the 1995 restoration project and two years before the1999 renourishment project. Results and conclusions of the present study are summarized below:

Results

- Four substrate classification types were found within the study area, including sand bottom with less than 10% rock, exposed rock with 10-50% algal sponge community cover, exposed rock with greater than 50% algal sponge community cover, and live worm rock.

- Based on the total transect length, the sand bottom with less than 10% cover occupied 53% of the total distance of all transects combined, while the remaining 43% was occupied by either the exposed rock with 10-50% cover type or the exposed rock with 10-50% cover type.

- Worm rock was observed as Dense Worm Rock along 11% of the total length of transects surveyed and Scattered Worm Rock along 25% of the total length of transects surveyed.

- Worm rock colonies were more commonly found on the more extensive rock outcrops close to shore than on the scattered smaller outcrops further offshore.

- The diversity of flora and fauna observed during the video was low due to poor visibility during the survey, but was characteristic of the biological communities associated with nearshore hardbottom habitat found along the east central and southeast coast of Florida.

- An analysis of trends in substrate cover types from 1994 to 2000 showed that the area of exposed rock with 10-50% biotic cover increased from 81.8acres to 93.7acres, while the area of exposed rock with greater than 50% cover decreased from 97.5acres to 60.5acres at both inshore and offshore areas.

- Temporal trends in distribution between the three substrate types were highly similar for most of the transects, including an increase in the greater than 50% substrate type between 1994 and 1997, followed by a significant reduction in cover by this type from 1997 to 2000. The 10-50% rock cover substrate type declined from 1994 to 1997 and increased from 1997 to 2000. The sand, less than 10% substrate cover type, generally increased at most transects over time from 1994 to 2000.

- Temporal changes from 1994 through 2000 in worm rock distribution along each transect were quite varied. Averaged for all the transects, the percentage of dense worm rock did not significantly change (12% to 11%) while the percentage of scattered worm rock declined from 43% to 25%.

- Only five of the seven permanent monitoring stations were found following an extensive search. Of the seven stations, photoquadrats were shot at stations PQ 4-7.

- The most common species of marine taxa observed at most of the stations include *Echinometra lucunter, Lytechinus variegatus,* and *Phragmatopoma lapidosa*.

- Worm rock colonies formed by *Phragmatopoma lapidosa* occurred at all four stations ranging in mean area from less than one percent at PQ-4, PQ-5 and PQ-6 to 18% at Station PQ-7, the station furthermost south.

- Due to limited visibility marine algae may have covered more area of the exposed rocks than identified through photographic analysis.

- Substrate, either rock or sand/shell, accounted for over 95% of the total area analyzed at three of the four stations. Rock coverage at Station PQ-7 was 79.8% due to the abundant cover of worm rock observed (18%).

- No spatial differences were apparent from the data presented except for an increase in worm rock cover at the southern study area limit and the lack of urchins observed at the southern inshore station (PQ-6) as compared to the other stations which were further offshore (PQ-4,5 and 7).

- The cover area of animals and plants were significantly less during the present monitoring event than previously observed. Biotic cover in 1994 ranged from 70-78% at stations PQ-4-7 and from <1% to 20% during the present study.

- This decline is likely due to a number of factors including the inability to accurately analyze photoquadrats in the present study due to the limited visibility, the differential growth rates of marine algae, the ephemeral nature of this shallow nearshore habitat, scouring of the rock habitat by sand in transport and the frequency and severity of storms since 1994, which has direct effects on algal cover.

Impact Assessment

- Based on a spatial comparison of substrate type locations from 1994 to present, 1.7 acres of rock habitat and their associated biological community were directly lost as a result of the 1995 and or 1999 projects. This loss included higher quality habitat characterized as exposed rock with greater than 50% algal- sponge community cover.

- Changes in habitat which occurred outside the fill limit included a loss of 8.4_acres of exposed rock with greater than 50% cover or 10-50% cover immediately seaward of the equilibrium tow of fill, reduction in 52.2 acres of habitat originally classified as exposed rock with greater than 50% cover or 10-50% cover to a cover type of sand, less than 10% exposed rock. An area of 8.4 acres classified as sand, less than10% exposed rock in 1994 was found to be exposed rock with 10-50% cover in 2000.

- Due to the natural dynamic changes inherent to nearshore rock habitat, most of the observed spatial changes in cover types may not be indirect impacts, however it is quite probable that the 8.4 acres of habitat indirectly lost immediately seaward of the equilibrium tow line is a result of stabilization of the beach profile and movement and redeposition of sand from the beach seaward over the rock outcrops.

- Observed spatial changes from 1994-2000 in the substrate cover types could be a result of seasonal differences in the occurrence of sessile marine invertebrates, temporary or seasonal deposition of a thin layer of sand over the level rock platform, the frequency and severity of storm events since the restoration projects, or other physical factors influencing the ephemeral exposure of rock and biotic cover.

- Since the origin of the sand now covering formerly exposed rock habitat is unknown, temporal changes in substrate cover types discussed above can not be only attributable to the beach restoration projects. While some of these observed changes may in fact be considered indirect impacts from the beach restoration projects, the exact area of impact can not be determined with the available information.

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APPENDIX A

Photoquadrat Analysis of Permanent Monitoring Stations

Representative Photoquadrat Photographs

APPENDIX A
Table A. Photoquadrat Analysis of Permanent Monitoring Stations

PQ4

Coverage Category	748777#4	Area	Mean	S.D.	Length
Echinometra lucunter	1	5806.55	226.73	74.91	270.18
Echinometra lucunter	2	7814.72	233.76	66.17	313.72
Echinometra lucunter	3	3925.97	88.62	80.96	222.8
Rock	4	406835.85			
Total	5	424383.09	72.26	72.81	2659.11

Coverage Category	748777#6	Area	Mean	S.D.	Length
Echinometra lucunter	1	5967813	123.46	100.46	8668.21
Echinometra lucunter	2	4487721	109.76	90.62	7526.72
Echinometra lucunter	3	4761048.5	70.74	71.77	7740.75
Lytechinus variegatus	4	5782157	51.81	39.2	8525.53
Rock		306154189			
Total	5	327152928	47.83	58.78	73941.42

Coverage Category	748777#8	Area	Mean	S.D.	Length
Rock	1	11305.85	72.5	72.37	467.56
Rock	2	2681.56	78.5	74.87	199.42
Rock	3	9054.5	94.62	76.03	379.36
Rock	4	5104.87	93.4	67.53	318.84
Rock	5	5890.9	89.97	65.27	310.84
Rock	6	2390.69	95.3	78.86	214.61
Sand Shell	7	158876.74			
Total	8	195305.11	90.94	74.11	1806.71

Coverage Category	748777#10	Area	Mean	S.D.	Length
Echinometra lucunter	1	5724742.5	72.97	64.15	8568.41
Echinometra lucunter	2	6481348	89.69	58.56	9495.92
Echinometra lucunter	3	4757837.5	223	62.79	7729.24
Sand Shell	4	486900392			
Total	5	503864320	100.22	78.9	91719.71

Coverage Category	748777#12	Area	Mean	S.D.	Length
Sabellariid Worms	1	47436.12	50.52	32.85	924.19
Sand	2	1095.61	57.74	33.27	149.9
Rock	3	116904.08			
Total	4	165435.81	56.29	45.6	1659.79

Coverage Category	748777#16	Area	Mean	S.D.	Length
Echinometra lucunter	1	1566673.75	82.66	51.65	4555.76
Echinometra lucunter	2	1439941.12	161.7	72.65	4310.1
Echinometra lucunter	3	1010424.69	88.47	51.63	3573.14
Echinometra lucunter	4	1415079.75	111.68	70.86	4421.76
Echinometra lucunter	5	5625.36	112.58	80.5	267.28
Sabellariid Worms	6	21892.38	90.72	64.8	624.88
Rock	7	122965971			
Total	8	128425608	102.65	69.67	46262.38

Coverage Category	748777#18	Area	Mean	S.D.	Length
Echinometra Lucunter	1	1537383.25	79.94	51.3	4398.11
Sand/Shell Hash	2	12590	75.96	55.83	549.03
Sand/Shell Hash	3	16707.59	76.98	53.5	715.54
Sand/Shell Hash	4	5255.69	77.04	60.27	346.65
Rock	5	99787655.5			
Total	6	101359592	79.88	55.29	41099.31

Coverage Category	748777#11	Area	Mean	S.D.	Length
Echinometra lucunter	1	950.85	58.78	52.38	109.34
Echinometra lucunter	2	1927.15	48.76	36.82	156.09
Unident Sponge	3	33223.32	73.34	65.21	835.3
Rock	4	126145.45			
Total	5	162246.77	74.87	65.15	1644.42

Coverage Category	748777#14	Area	Mean	S.D.	Length
Total/Rock	1	137380784	93.28	73.82	47804.81

Coverage Category	748777#26	Area	Mean	S.D.	Length
Echinometra lucunter	1	2521260.25	76.16	66.16	5628.46
Echinometra lucunter	2	1500412.75	64.35	53.01	4464.77
Echinometra lucunter	3	1883973.5	89.78	48.58	5960.94
Echinometra lucunter	4	3648627.25	87.54	66.3	6768.4
Echinometra lucunter	5	2416341.25	82.47	65.97	5509.71
Echinometra lucunter	6	2270734.5	102.02	75.96	5343.47
Unident Hydroid	7	56699.72	111.88	77.01	1601.8
Rock	8	130636703			
Total	9	144934752	93.5	67.25	49197

PQ5

Coverage Category	748778#1	Area (mm^2)	Mean	S.D.	
Echinometra lucunter	1	45.7	186.6	49.21	
Echinometra lucunter	1	99.41	182.86	53.89	
Echinometra lucunter	1	30.46	178.74	59.72	
Echinometra lucunter	1	44.44	187.48	50.79	
Echinometra lucunter	1	73.07	191.63	40.99	
Rock	2	171.79	134.25	36.45	
Rock	2	353.12	156.32	40.4	
Rock	2	668.37	145.66	33.74	
Rock	2	3394.53	157.26	54.09	
Rock	2	314.75	180.85	37.8	
Rock	2	552.78	170.53	48.24	
Rock	2	127.24	159.52	63.82	
Sand	3	279.06	127.07	30.5	
Sand	3	48.02	149.74	51.48	
TOTAL	15	276593.53	148.64	61.55	2139.04

Coverage Category	748778#3	Area (mm^2)	Mean	S.D.	Length
Rock/Total	1	182712.09	102.14	79.12	1745.49

Coverage Category	748778#5	Area (mm^2)	Mean	S.D.	Length
Sabellariid worm	1	47620.59	85.61	72.13	1548.43
Echinometra lucunter	2	1485.12	140.2	81.06	142.45
Rock	3	115257.71	106.97	79.89	2875.61
Total	4	163280.7	108.55	79.94	1650.41

Coverage Category	748778#7	Area (mm^2)	Mean	S.D.	Length
Sabellariid Worms	1	15739.07	75.33	55.06	477.15
Lytechinus variegatus	2	7801.91	72.65	56.02	313.06
Echinometra lucunter	3	3679.83	80.28	58.47	253.01
Echinometra lucunter	3	1002.01	74.85	44.92	112.07
Echinometra lucunter	3	4505.22	110.73	67.51	239.89
Rock		195822.02			
Total	6	228550.06	93.01	64.4	1950.54

Coverage Category	748778#9	Area (mm^2)	Mean	S.D.	Length
Sand	1	25762.26	76.44	61.83	1161.77
Sand	2	21680.49	86.73	75.33	1259.68
Sand	3	8723.81	87.49	78.67	624.95
Sand	4	4462.48	95.73	69.52	293.15
Sand	5	7765.18	124.54	51	375.85
Sand	6	1531.65	88.52	63.06	172.44
Rock		560706.01			
Total	7	630631.88	113.64	77.89	3247.04

Coverage Category	748778#4	Area (mm^2)	Mean	S.D.	Length
Sabellariid Worms	1	31325.82	91.64	70.49	797.56
Sand	2	729.14	90.19	83.66	135.5
Sand	2	5005.83	77.5	79.87	361.47
Sand	2	1179.64	69.36	73.41	139.96
Rock	5	127045.8	89.83	76.94	1695.3
Total	3	179414.27	89.82	75.42	1729.67

Coverage Category	748778#8	Area (mm^2)	Mean	S.D.	
Undi Green Algae	1	4333.35	66.12	41.23	313.54
Undi Green Algae	1	922.2	52.61	36.51	131.24
Undi Green Algae	1	37286.14	149.44	86.7	1453.55
Sand	2	66119.65	105.89	70.26	
Sand	2	32554.41	106.38	73.73	
Total	3	366099.72	110.75	76.24	

Coverage Category	748778#11	Area (mm^2)	Mean	S.D.	Length
Sabellariid Worms	1	50652.38	80.75	72.49	1123.77
Sabellariid Worms	2	25463.79	80.92	55.22	755.13
Echinometra lucunter	3	1897.6	92.5	52.35	160.65
Echinometra lucunter	4	2828.35	84.26	63.28	208.38
Echinometra lucunter	5	1498.96	66.68	55.59	150.18
Echinometra lucunter	6	544.83	130.85	72.55	89.83
Rock	7	107952.42			
Total	8	190838.33	98	75.93	1784.35

Coverage Category	748778#13	Area (mm^2)	Mean	S.D.	Length
Sabellariid Worms	1	44919.22	90.41	74.96	919.36
Sabellariid Worms	2	28414.76	92.78	72.75	737.75
Unid. Green Algae	3	4642.76	80.87	68.12	398.56
Rock		185232807.3			
Total	4	185310784	93.16	73.43	55585.74

Coverage Category	748778#15	Area (mm^2)	Mean	S.D.	Length
Echinometra lucunter	1	4484.31	64.7	44.91	328.66
Echinometra lucunter	1	5988.38	88.9	78.8	299.54
Sabellariid Worms	2	21259.38	78.67	50.09	662.78
Sabellariid Worms	2	181141.58	78.03	63.27	1787.12
Unid. Algae	3	19985.04	62.37	57.31	538.45
Rock		385343.93			
Total	4	618202.62	95.43	74.96	3213.18

PQ6

Coverage Category	748782#2	Area	Mean	S.D.	Length
Sabellidarid Worms	1	47243.91	103.54	77.58	1296.55
Sand Shell	2	175531.44	94.68	74.33	1984.04
Total	3	222620.48	96.51	75.02	1921.01

Coverage Category	748782#4	Area	Mean	S.D.	Length
Total/Sand	1	409565696.00	71.94	52.79	82582.59

Coverage Category	748782#6	Area	Mean	S.D.	Length
Sabellariid Worms	1	110711.47	76.7	62.88	1679.98
Cliona deltrix	2	3993.67	63.14	57.72	304.35
Rock	3	52857.02			
Total	4	167562.16	91.99	78.09	1669.54

Coverage Category	748782#10	Area	Mean	S.D.	Length
Unid. Green Algae	1	3428.56	110.84	58.83	301.58
Rock	2	108557971.44			
Total	3	108561400.00	94.49	64.98	42464.45

Coverage Category	748782#12	Area	Mean	S.D.	Length
Unid. Algae	1	13884.46	82.7	64.91	1004.36
Sand	2	110051507.54			
Total	3	110065392.00	92.59	74.06	42733.02

Coverage Category	748782#14	Area	Mean	S.D.	Length
Unid. Green Algae	1	23995.17	87.5	59.48	657.7
Unid. Green Algae	2	1596.17	73.67	51.32	154.25
Unid. Green Algae	3	5982.94	102.84	71.8	350.44
Unid. Green Algae	4	869.13	94.14	70	114.07
Unid. Green Algae	5	15522.39	86.13	51.97	632.11
Unid. Green Algae	6	8481.70	89.72	58.23	390.6
Sand	7	120698648.50			
Total	8	120755096.00	92.52	67.88	44811.97

Coverage Category	748782#16	Area	Mean	S.D.	Length
Sabellariid Worms	1	86921.26	81.94	54.97	1199.56
Sand/Shell	2	103316182.74			
Total	3	103403104.00	87.99	60.89	41425.16

Coverage Category	748782#18	Area	Mean	S.D.	Length
Sabellariid Worms	1	32198.49	100.65	82.33	701.08
Unid. Green Algae	2	27602.14	71.73	53.93	922.55
Unid. Green Algae	3	22966.14	80.24	62.57	568.14
Sand	4	119854241.23			
Total	5	119937008.00	84.01	67.49	44689.09

Coverage Category	748782#20	Area	Mean	S.D.	Length
Sabellariid Worms	1	62736.25	70.13	52.53	559.56
Sand	2	108096871.75	73.3	57.67	856.5
Total	3	108159608.00	88.07	68.22	42446.96

Coverage Category	748782#22	Area	Mean	S.D.	Length
Sabellariid Worms	1	9532.16	77.81	62.06	374.32
Sand	2	165965.45			
Total	3	175497.61	99.15	72.08	1708.86

PQ7

Coverage Category	7000#1	Area	Mean	S.D.	Length
Echinometra lucunter	1	2735.25	83.42	57.2	185.4
Echinometra lucunter	2	1267.03	90.2	59.03	131.6
Echinometra lucunter	3	2041.15	86.12	56.12	160.42
Echinometra lucunter	4	3950.67	107.79	69.92	226.7
Echinometra lucunter	5	1411.01	88.83	50.35	136.4
Echinometra lucunter	6	1393.06	198.51	81.6	144.09
Echinometra lucunter	7	3033.42	61.22	37.94	217.61
Cliona delitrix	8	572.56	105.44	81.87	107.01
Rock	9	221782.93			
Total	10	237614.52	85.78	64.34	1989.93

Coverage Category	7000#3	Area	Mean	S.D.	Length
Echinometra lucunter	1	6766.97	123.64	52.41	292.01
Echinometra lucunter	2	3343.23	64.14	49.49	205.31
Echinometra lucunter	3	5247.72	65.81	48.72	258.13
Echinometra lucunter	4	2302.62	110.03	53.19	170.42
Echinometra lucunter	5	2557.04	62.95	39.43	179.39
Sabellariid Worms	6	12699.36	64.82	49.64	599.05
Rock	7	236868.5	71.5	51.73	1311.44
Total	8	257086.08	77.76	54.62	2069.65

Coverage Category	7000#5	Area	Mean	S.D.	Length
Echinometra lucunter	1	2821.99	97.89	65.34	188.28
Cliona delitrix	2	1348.31	84.7	71.94	185.01
Rock	3	183786.39	83.83	66.43	1703.26
Total	4	187956.69	88.88	66.38	1768.9

Coverage Category	7000#7	Area	Mean	S.D.	Length
Echinometra lucunter	1	2117.42	226.8	57.09	179.48
Echinometra lucunter	2	1127.89	201.06	63.06	151.96
Echinometra lucunter	3	1151.35	134.93	87.52	126.89
Echinometra lucunter	4	1502.43	79.99	68.9	137.88
Echinometra lucunter	5	2370.97	68.18	56.47	172.56
Echinometra lucunter	6	2195.43	70.19	57.39	171.7
Echinometra lucunter	7	1569.78	88.24	68.45	154.15
Echinometra lucunter	8	1605.74	94.2	74.63	179.19
Echinometra lucunter	9	702.45	71.79	50.91	120.25
Echinometra lucunter	10	2314.29	99.77	47.45	200.53
Rock	11	176875.02			
Total	12	193532.77	90.53	70.43	1796.35

Coverage Category	7000#9	Area	Mean	S.D.	Length
Echinometra lucunter	1	2712.77	87.74	50.93	185.14
Echinometra lucunter	2	2588.25	97.36	55.3	180.29
Echinometra lucunter	3	3745.1	174.32	81.83	217.13
Echinometra lucunter	4	5021.52	92.95	69.33	255.9
Echinometra lucunter	5	2303.04	117.85	67.36	175.45
Sabellariid Worms	6	99885.55	108.39	68.4	1934.49
Rock	7	125442.89			
Total	8	241699.12	105.16	70.4	2006.76

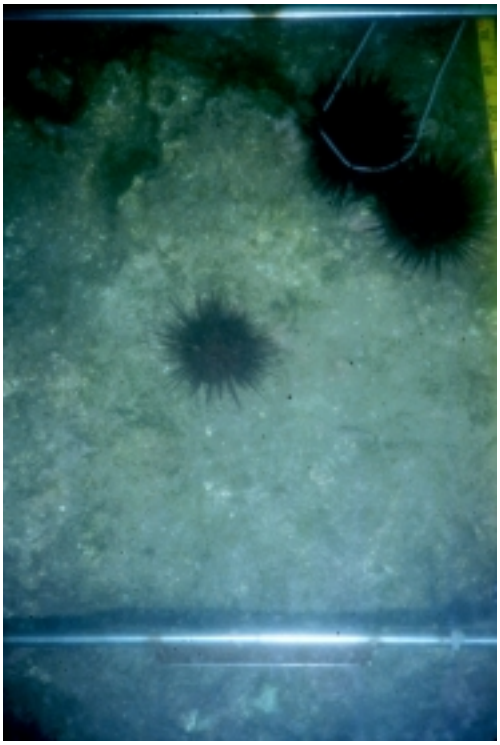
Coverage Category	7000#11	Area	Mean	S.D.	Length
Echinometra lucunter	1	2599.73	85.81	64.17	181.79
Sabellariid Worms	2	157221.8	84.95	66.03	1604.54
Rock	3	5154.41			
Total	4	164975.94	94.66	73.32	1656.93

Coverage Category	7000#13	Area	Mean	S.D.	Length
Echinometra lucunter	1	1608.61	80.85	71.09	156.35
Sabellariid Worms	2	60297.96	80.57	62.02	987.96
Sabellariid Worms	3	37104.8	81.72	69.19	745.81
Sabellariid Worms	4	17559.01	79.31	71.52	696.63
Rock	5	93211.64			
Total	6	209782.02	84.3	67.1	1871.3

Coverage Category	7000#15	Area	Mean	S.D.	Length
Echinometra lucunter	1	3812.88	86.28	53.66	233.44
Sabellariid Worms	2	10185.02	92.65	63.09	411.73
Rock	3	206703.66			
Total	4	220701.56	87.3	58.55	2192.12

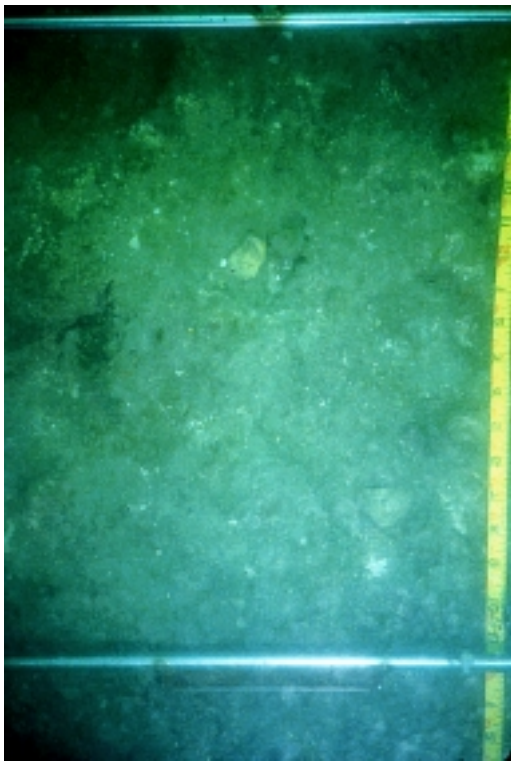
Coverage Category	7000#17	Area	Mean	S.D.	Length
Total/Rock	1	184608.86	92.62	68.41	1752.67

Coverage Category	7000#19	Area	Mean	S.D.	Length
Sabellariid Worm	1	164986.34	73.29	57.52	1844.12
Sabellariid Worms	2	24815.58	73.99	58.04	1856.89
Rock	3	1159252.83			
Total	4	1349054.75	75.33	58.17	4739.33

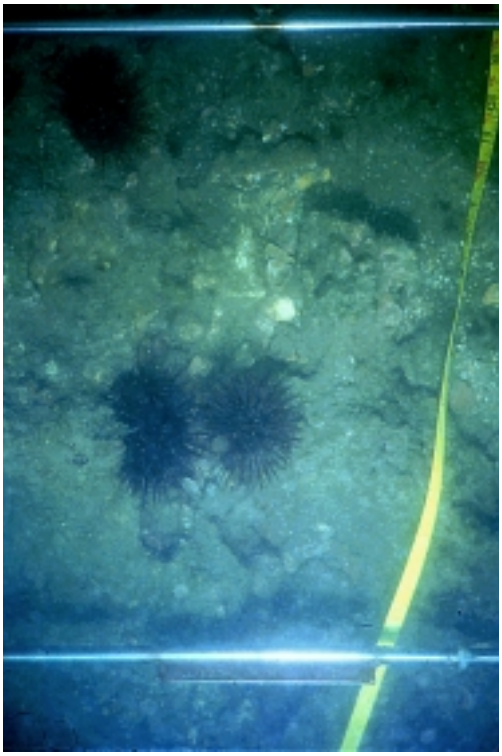


Representative photoquadrat with sea urchin, *Echinometra lucunter*, and rock at Station PQ4.

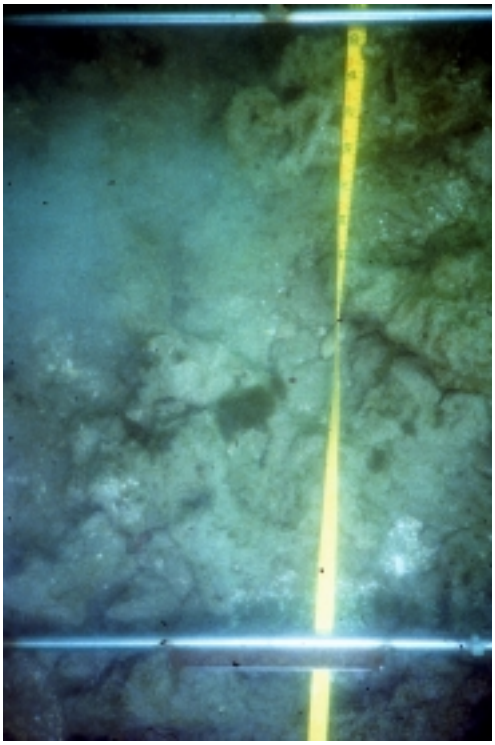
Photoquadrat at Station PQ4 with *Lytechinus variegatus*, *Echinometra lucunter*, and rock substrate.



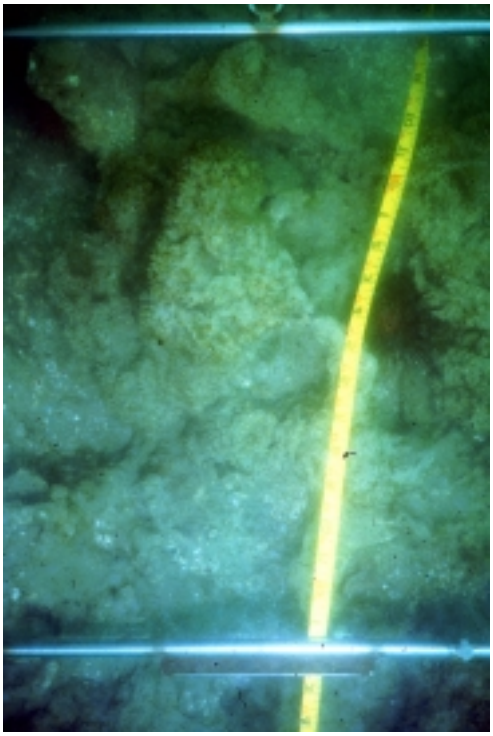
Photoquadrat at Station PQ4 with rock and sand/shell substrate.



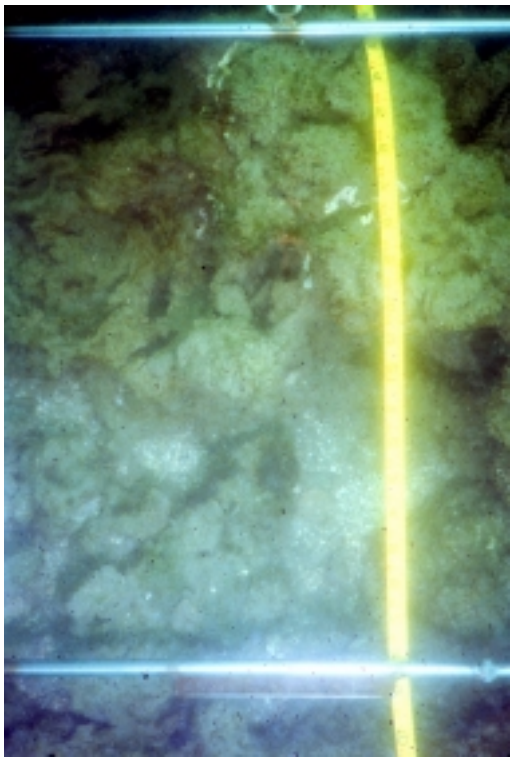
Photoquadrat at Station PQ4 with *Lytechinus variegatus*, rock, and shell substrate.



Photoquadrat at Station PQ5 with *Phramatopoma lapidosa* colonies, rock, and sand/shell substrate.

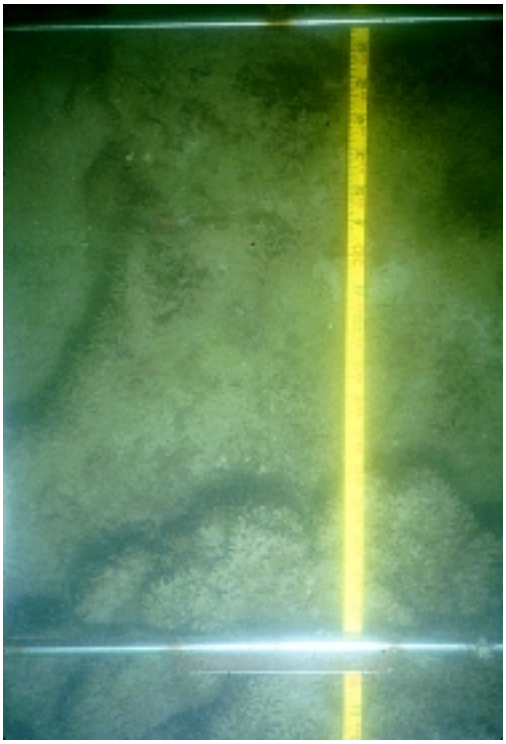


Photoquadrat at Station PQ5 with *Phramatopoma lapidosa* and *Echinometra lucunter.*

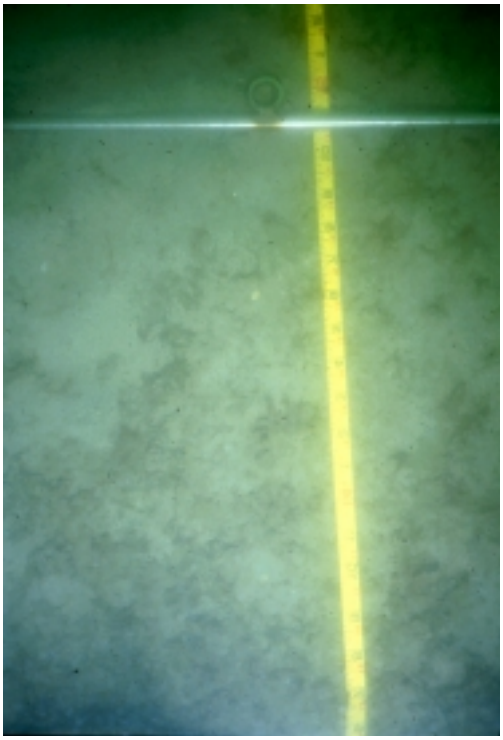


Photoquadrat at Station PQ5 with *Phramatopoma lapidosa* colonies, green algae, and rock cover types.

Photoquadrat at Station PQ5 with worm rock colonies, sea urchins, and rock substrate.



Photoquadrat at Station PQ6 with live worm rock, rock, and sand substrate.

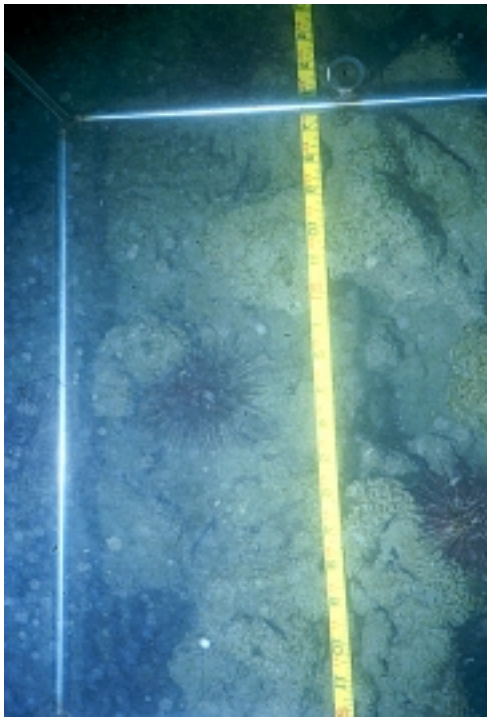


Rock with sand/shell substrate and marine algae at Station PQ6.

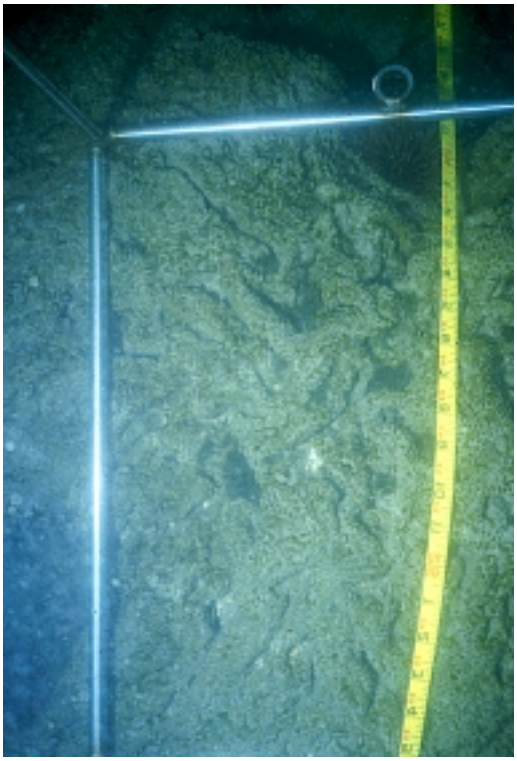
Live worm rock colonies, algae, and sand/shell at Station PQ6.

Photoquadrat at Station PQ6 with *Phragmatopoma lapidosa* and sand/shell substrate.

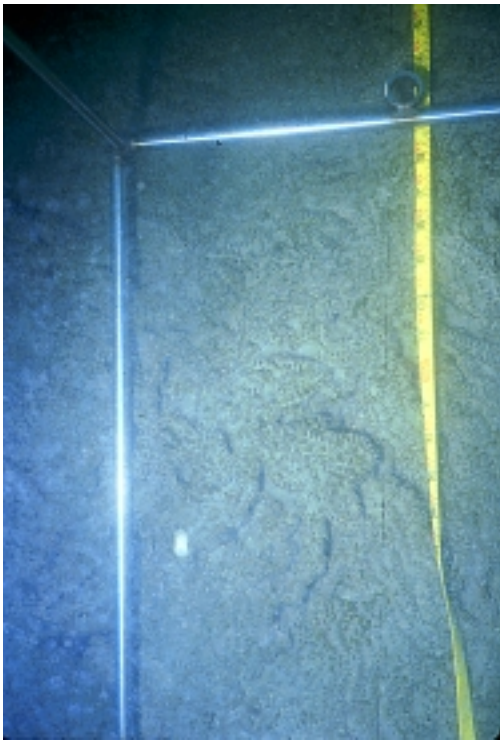
Photoquadrat at Station PQ7 with *Echinometra lucunter* and rock substrate.



Worm rock, *Echinometra lucunter* and rock substrate at Photoquadrat Station PQ7.



Sabellariid worm rock at Photoquadrat Station PQ7.



Sabellariid worm rock at Photoquadrat Station PQ7.